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VITAMIN B IN THE EDIBLE TISSUES OF THE OX, SHEEP, AND HOG.

I. VITAMIN B IN THE VOLUNTARY MUSCLE.
II. VITAMIN B IN THE EDIBLE VISCERA.

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VITAMIN B IN THE DIET.

Vitamin B, also known as the antineuritic vitamin, is one of those chemically unidentified substances which are absolutely necessary for the growth and maintenance of man and animals. The disease known as beriberi, formerly rather common among the rice-eating people of the East, is due to the consumption of a diet made up very largely of polished rice, which is very deficient in this vitamin. On the other hand, natives who subsist largely on the unpolished cereal do not contract beriberi, and the disease may be cured simply by substituting unpolished for polished rice in the diet. A less-marked deficiency of vitamin B in the diet results in retarded growth and other disorders. Birds fed a diet very deficient in vitamin B lose weight rapidly and develop polyneutritis, while young rats make but slight, if any, growth on such a diet. Since the chemical identity of vitamin B or of any of the other vitamins is not known, the only reliable method for the estimation of the vitamin content of a foodstuff is by animal experimentation. This method has its limitations, but when feeding tests are carried on with the greatest care and the results are interpreted with caution, fairly accurate, relative vitamin values may be assigned to the foods tested.

Considering the fact that practically all our knowledge concerning vitamins has been acquired only during the last decade, we have a very considerable amount of information regarding the

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values of the important foodstuffs in terms of vitamins A, B, and C. The data are far from sufficient, however, for the purpose of assigning other than tentative values to many of our staple food products. Meat, for example, one of our most important foodstuffs, has been assigned a rather low value as a source of the three vitamins; but a careful review of the literature indicates that only a limited number of investigations have been carried on to determine the vitamin content of this food, and that practically all the work has been done with beef and horse meat. The validity of the work which has been done is not questioned, but it is too limited in amount to justify the statement that meat in general is poor in vitamins. Certain animal organs, on the other hand, particularly the heart, liver, and kidney, have been found to be relatively rich in the three vitamins.

Additional information regarding the vitamin content of meat, which should include not only beef, but veal, mutton and lamb, and pork as well, is much to be desired, as well as data concerning the vitamin content of the edible organs and other tissues of the meat food animals. It is the purpose of this bulletin to report the results of investigations that have been carried on to determine the vitamin-B content of the voluntary muscle and the edible organs of the ox, sheep, and hog.

I. VITAMIN B IN THE VOLUNTARY MUSCLE OF THE OX, SHEEP, AND HOG.

IMPORTANCE OF MEAT AS A FOOD.

Meat long has been and still is one of the most important articles of food in the dietary of the American people. In pounds, its per capita consumption for the year 1922 (*1*) [1] was as follows: Beef, 57.7; veal, 8.3; mutton and lamb, 6.1; and pork, excluding lard, 72.8; a total of 144.9 pounds per year, or 0.4 pound per day. According to Langworthy and Hunt, (*2*) (1910) meat forms, together with poultry, 16 per cent of the aggregate American dietary as compared with 18 per cent for dairy products, 25 per cent for fruits and vegetables, and 31 per cent for cereals and their products. Meat also furnishes 30 per cent of the protein and 59 per cent of the fat in the dietary. Even more striking is the relatively large expenditure for meat as compared with other classes of foods. Sherman (*3*) (1918) states that as a result of a dietary study of 2,567 workingmen's families, the United States Bureau of Labor Statistics found that the average expenditure for meat, poultry, and fish amounted to 33.8 per cent of the total sum expended for foods.

PREVIOUS INVESTIGATIONS WITH MEAT.

Eykman (*4*) (1906) reports that he cured polyneuritic fowls with raw meat, but the kind and quantity fed are not stated.

Watson and Hunter (*5*) (1906) carried on feeding tests with rats to ascertain the effect of exclusive horseflesh and ox-flesh diets, respectively, upon very young and mature animals. When horseflesh was fed to very young rats the result was invariably fatal. Young rats 2 to 3 months old did somewhat better on the diet, but

[1] Italic figures in parentheses refer to Literature cited, p. 46.

part of them died early in the test, while the others did fairly well, though their growth was retarded. Ox flesh gave rather better results. A part of the very young rats died early, while the remainder grew fairly well but did not attain normal weight. Young rats 2 to 3 months old did well on the diet, reaching greater weights than the controls.

Cooper (*6*) (1912) appears to have been the first to study systematically the antineuritic properties of muscle (beef). Five lots of pigeons of five birds each were fed polished rice, and in addition the birds in the several pens were fed daily 2, 4, 6, 10, and 20 grams each, respectively, of fresh beef. The results of this test indicate that the daily addition of 20 grams of fresh beef to the rice diet was necessary in order to prevent the development of polyneuritis in pigeons during a period of 50 days. The average weight of the pigeons receiving 20 grams each of beef daily was slightly greater at the close of the test than at the start; but the addition of less than 20 grams of beef daily to the diet was only sufficient either to delay the occurrence of the symptoms of the disease or to reduce their severity.

Osborne and Mendel (*7*) (1917) found that a diet containing 20 per cent of dried ox muscle as the sole source of vitamins and protein, and otherwise adequate, did not induce growth in young rats. The addition of butterfat to the ration did not improve its quality; but when dried yeast was added, normal growth took place. A ration containing 5 per cent of water-soluble solids of fresh beef, which would correspond to 28.9 per cent of dried muscle, did not induce normal growth in rats, although somewhat better results were obtained than with the ration that contained 20 per cent of dried muscle.

Cole (*8*) (1917) fed a dried-meat powder prepared from the lean meat of South American cattle to young rats, the meat amounting to 26.8 per cent of the ration. The meat was the sole source of protein and vitamins. The rats made satisfactory growth during a 14-day period and the author concludes that the product contains a good supply of the accessory food factors.

Voegtlin and Lake (*9*) (1919) studied the antineuritic properties of beef when fed to dogs, cats, and rats. Two cats were maintained for 180 days in perfect health on an exclusive diet of beef that had been heated for 3 hours at 120° C. Two pregnant cats fed the same ration developed polyneuritis in 45 and 110 days respectively. The authors call attention to the great difference in the susceptibility of dogs, cats, and rats to polyneuritis when fed the same ration. When fed exclusively on beef that had been heated for 3 hours at 120° C. in the presence of sodium carbonate, cats developed polyneuritis as early as the eighteenth day, dogs at a month to 6 weeks, and rats lived for at least 110 days without showing symptoms of the disease.

McCollum, Simmonds, and Parsons (*10*) (1921) investigated the nutritive value of ox muscle when fed to white rats. Two lots of rats were fed rations in which the vitamins were furnished exclusively in 25 per cent of dried raw and 25 per cent of dried cooked muscle, respectively. In both lots growth ceased at the end of about four weeks. Five per cent of butterfat was then added to each of the rations and there was a marked response in growth. In another test, rats fed a ration containing 20 per cent of ox muscle and vitamin A in the form of 3 per cent butterfat made fair but not normal growth. Another lot of rats fed exclusively on ox muscle made little

growth, had no young, and died early. Rats fed a ration consisting of ox muscle, calcium carbonate, sodium chlorid and 3 per cent butterfat grew at practically the normal rate and appeared healthy. When rats were fed a ration containing 50 per cent ox muscle and 3 per cent butterfat, they made normal growth. Rats were raised to the third generation on this diet with reasonable success. Another lot of rats, fed for a period exclusively on ox muscle, made but little growth. The addition of sodium chlorid and calcium carbonate to the diet was followed by a slight response in growth. Rats fed a ration containing 50 per cent ox muscle, sodium and potassium chlorids, calcium carbonate, dextrin, and butterfat made normal growth and the second and third generations were raised successfully on this diet.

EXPERIMENTAL WORK.

METHODS EMPLOYED.

The purpose of the experiments reported in Part I of this paper was to ascertain the antineuritic properties of the voluntary muscle of the ox, sheep, and hog when fed to pigeons in connection with polished rice. The pigeons used were of the homer type, healthy, mature birds weighing between 300 and 400 grams being selected. Four or five birds were fed each ration at the start, but occasionally a bird would have to be removed during the test on account of an injury.

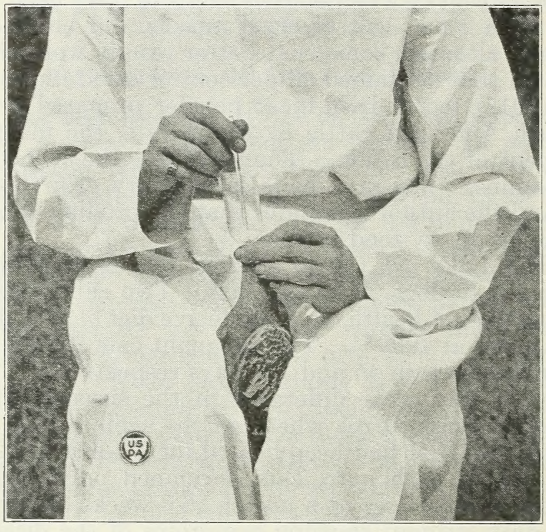

FIG. 1.—Method of feeding the pigeons.

The pigeons were weighed individually before feeding on the first day of the test and at approximately weekly intervals thereafter, always before feeding. Each bird was fed daily, except Sunday, a ration amounting to 5 per cent by weight of the initial weight of the pigeon. Forced feeding was practiced throughout the experiments. The ration was fed into the crop of the pigeon through a Gooch funnel having a bowl $1\frac{1}{2}$ inches in diameter and a stem 3 inches long with an inside diameter of $\frac{1}{4}$ inch, a glass rod being used as a plunger.

When proper care is used, very few birds are injured by this method of feeding. The method is illustrated in Figure 1.

The meat used in these tests was of the best quality. It was purchased in the local market and no information was available regarding the feeding of the animals from which the meat had been derived. The muscle tissue was trimmed as free as practicable from fat and connective tissue, ground fine, and mixed with water and toluol to form a semifluïd mass which was spread out in a thin layer on shallow trays and dried in a forced current of air at a maximum temperature

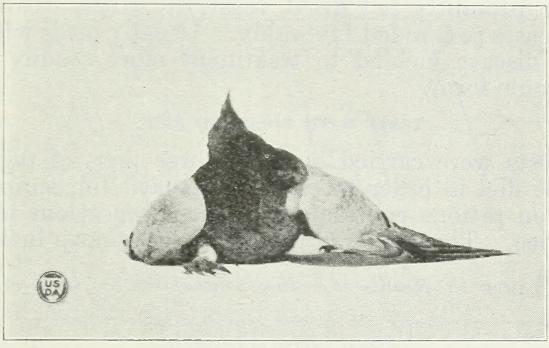

FIG. 2.—Pigeon with acute polyneuritis, showing lack of control of muscles in the wings, legs, and neck.

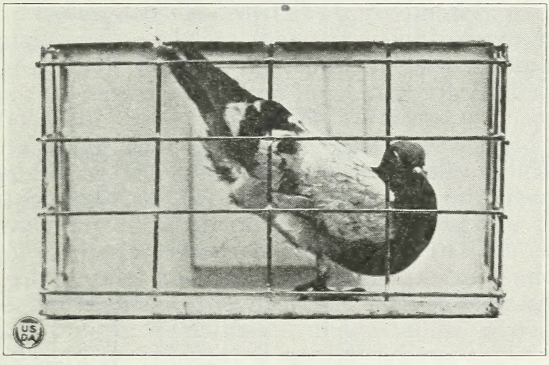

FIG. 3.—The same pigeon as in Fig. 2, 24 hours later, after having been fed 15 grams of dried smoked ham. The bird is a little unsteady on its feet but shows no acute symptoms of the disease.

of 60° C. Drying was carried on in a simple oven designed by the writer, its capacity being 5 kg. of fresh tissue to air dryness in 24 hours. The dried tissue was ground fine and stored in stoppered bottles until needed. The moisture content of the dry tissue ranged from 4 to 8 per cent.

The rice used was the ordinary polished rice of commerce. It was ground medium fine and, unless otherwise stated, was heated two hours in an autoclave at 130° C. before being used.

The term "survival period" as used in this paper denotes the period between the start of the experiment and (1) the development

of positive symptoms of polyneuritis, (2) death due apparently to polyneuritis, or (3) the close of the test.

It is not necessary to describe the symptoms of polyneuritis in pigeons, as they have been fully stated by other writers. The symptoms of acute polyneuritis are unmistakable. However, even on a polished-rice diet, not all birds develop this type of the disease, but some may exhibit a chronic form, usually first indicated by the regurgitation of food, later by inability to empty the crop, weakness in the legs, etc., followed by general prostration, partial paralysis, difficult breathing, collapse, and death. As a rule, polyneuritic pigeons were promptly fed dried yeast, to which treatment most, but not all, cases responded favorably. Usually birds with the acute type of the disease yielded to treatment more readily than those with the chronic form.

TESTS WITH POLISHED RICE.

Feeding tests were carried on with three pens of pigeons on an exclusive rice diet in order to establish a basis for comparison with pigeons fed on rations containing various proportions of muscle in addition to rice. The results of these tests are shown in Table 1.

TABLE 1.—*Results of feeding polished rice to pigeons.*

Ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 1.		*Days.*	*Per cent.*	
Rice not heated	73	19	−20.7	Polyneuritis.
Do	70	21	−15.0	Do.
Do	72	35	−17.8	Very thin, weak, end of test.
Do	74	35	−31.7	Do.
Average		27.5	−21.3	
PEN 2.				
Rice heated 2 hours at 130° C	79	17	−20.0	Polyneuritis.
Do	77	21	−23.3	Do.
Do	76	30	−39.3	Do.
Do	78	35	−36.9	Very thin, weak, end of test.
Average		25.6	−29.9	
PEN 3.				
Rice heated 2 hours at 130° C	66	9	−5.8	Polyneuritis.
Do	38	11	−13.0	Do.
Do	64	18	−23.3	Do.
Do	67	18	−19.9	Do.
Do	69	21	−22.4	Do.
Average		15.4	−16.9	
Average, pens 2 and 3		20.5	−23.4	
Average, pens 1, 2, and 3		22.8	−22.7	

The data presented in Table 1 do not require a detailed discussion. Attention is called to the difference in the survival period of birds in a single pen on the same ration. The average survival period of the birds in pens 2 and 3, getting heated rice, is seven days less than that of the pigeons in pen 1 on the unheated-rice ration; but the loss in weight is about the same. The survival period of the birds in pen 3 is 12 days less than that of pen 1. In addition to these results, the writer has found that when an animal tissue, like liver, normally

of high antineuritic value is heated in an autoclave for two hours at 130° C. its protective properties are practically destroyed. For these reasons all the polished rice which was used in subsequent experiments as a base in the rations with muscle, was heated two hours at 130° C. in an autoclave. The change in weight of the pigeons in pens 1, 2, and 3 is shown graphically in Figure 4, at the end of this paper. The marked and rapid decrease in the weights of the birds is at once apparent.

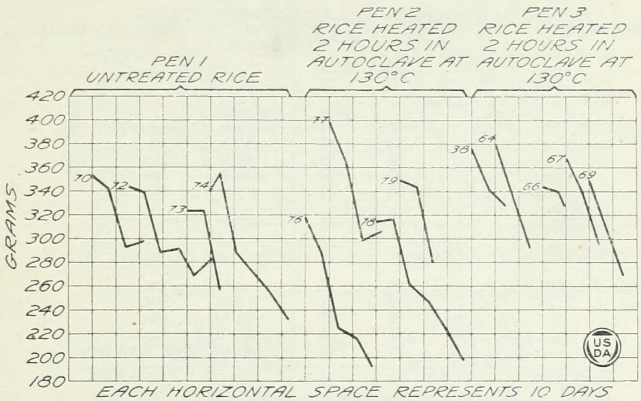

FIG. 4.—Variations in weight of pigeons resulting from feeding polished rice. The numbers opposite beginnings of lines refer to Pigeon Nos. of tables.

The graphs presented in Figures 4 to 45, inclusive, are based upon the weights of the pigeons recorded at approximately weekly intervals during the experiments, except that the weight of any bird suffering from a congestion of food in its crop, an early symptom of polyneuritis, was not recorded. Since most pigeons that develop polyneuritis suffer from this condition of the crop, it was found to be inadvisable to weigh each bird at the time it developed polyneuritis. For this reason, then, the graph of a pigeon usually indicates a shorter period than the survival period for the same bird recorded in the table. Occasionally a graph may indicate a slightly longer period than the survival period shown in the table. In such cases the crop of the bird was normal and the last weighing was made a few days after the development of the disease. The percentage change in weight of each pigeon, as indicated in the tables, is based upon the initial weight and upon the last normal weight as shown in the graph for the same bird. The graphs are presented distinctly for the purpose of showing at a glance the rate and extent of the change in weights of the pigeons during the experiments, and not for the purpose of indicating the survival periods of the birds.

TESTS WITH OX MUSCLE.

The results of the feeding tests with ox muscle are shown in Tables 2, 3, and 4, and the changes in the weights of the birds are shown graphically in Figures 5, 6, 7, 8, 9, and 10.

Pens 4 and 5 (Table 2) were fed rations containing 25 and 15 per cent, respectively, of muscle derived from the round of the carcass of a single fat steer. The slight difference in the average survival periods of the two pens of birds is not material. There was prac-

tically no difference in the average loss in weight of the two pens of birds. By referring to Table 1 it will be noted that the average survival period of the birds in pens 2 and 3, which were fed autoclaved rice alone, was 20.5 days, or practically the same as that of pens 4 and 5 on the ox-muscle rations.

TABLE 2.—*Experimental feeding of dried ox muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 4.				
		Days.	*Per cent.*	
25 per cent round No. 553	80	14	−12.0	Polyneuritis.
Do	75	17	−15.4	Do.
Do	68	19	−18.0	Do.
Do	85	20	−24.7	Do.
Do	90	24	−8.4	Do.
Average		18.8	−15.7	
PEN 5.				
15 per cent round No. 553	96	12	−4.1	Do.
Do	98	14	−5.5	Do.
Do	97	17	−16.3	Do.
Do	48	19	−10.9	Do.
Do	95	45	−35.0	Died, inanition
Average		21.4	−14.4	
PEN 6.				
25 per cent chuck No. 568	8	13	−5.0	Polyneuritis.
Do	10	24	−11.4	Do.
Do	9	26	−8.7	Do.
Do	7	37	−20.6	Do.
Average		25	−11.4	
PEN 7.				
25 per cent sirloin No. 569	13	20	−2.5	Do.
Do	11	23	−11.6	Do.
Do	12	25	−16.0	Do.
Do	14	55	−25.5	Alive, very thin, end of experiment.
Average		30.8	−13.9	
PEN 8.				
25 per cent round No. 589 dried at room temperature.	32	13	−10.4	Polyneuritis.
Do	33	24	−22.4	Do.
Do	31	25	−9.7	Do.
Do	35	55	−36.0	Alive, very thin, end of test.
Average		29.2	−19.6	

Pen 6 was fed a ration containing 25 per cent of muscle taken from the shoulder of another fat carcass of beef. The slightly longer survival period and smaller loss in weight indicate a somewhat higher antineuritic value for this sample of muscle than for that fed to pens 4 and 5.

Pen 7 was fed a ration which contained 25 per cent of muscle taken from the loin of another fat carcass of beef. The survival period of this pen of birds was slightly longer than that of pen 6 getting 25 per cent of muscle from the round, but this difference is due to the survival of pigeon 14 in pen 7 at the end of the test, although it was in very poor condition at that time. The three other birds in this pen developed polyneuritis on the twentieth, twenty-third, and twenty-fth days. In reality, there was probably no material difference in

the antineuritic value of the muscle from the loin as compared with that of the muscle from the shoulder.

The muscle fed to pen 8 was taken from the round of another fat carcass of beef and dried at room temperature (25° to 30° C.). The result obtained with this pen is very similar to that described for pen 7. On the other hand, pen 4, fed a ration containing 25 per cent of muscle from the round of another carcass, the tissue being dried

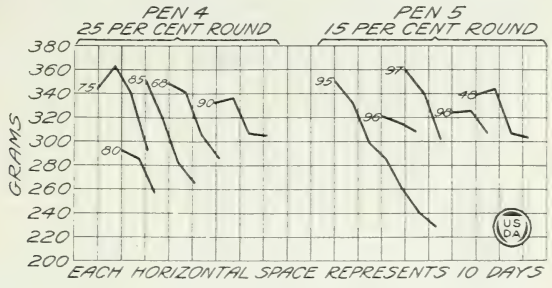

FIG. 5.—Dried ox muscle; changes in weights of pigeons fed.

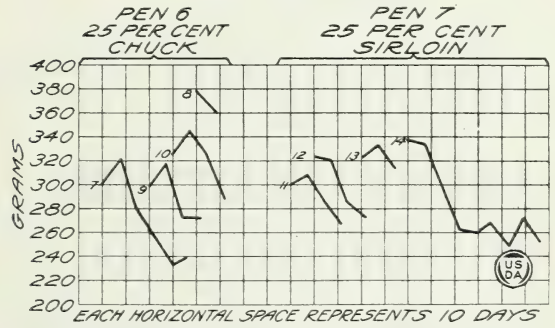

FIG. 6.—Dried ox muscle; changes in weights of pigeons fed.

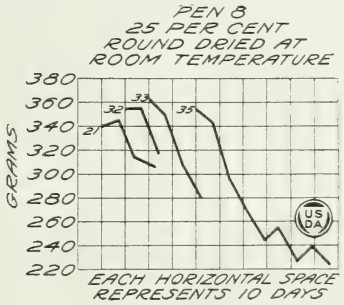

FIG. 7.—Dried ox muscle; changes in weights of pigeons fed.

at 60° C., had a much shorter survival period, 18.8 days as compared with 29.2 days for pen 8. This difference is probably due to the fact that pen 8 contained one very resistant bird, No. 35, while in pen 4 all the birds developed polyneuritis by the twenty-fourth day. The three other birds in pen 8 developed polyneuritis by the twenty-fifth day. Apparently the muscle dried at room temperature had no greater antineuritic value than that dried at 60° C.

Pens 9 and 10 were fed rations containing 15 and 25 per cent, respectively, of ox tongue. Approximately a dozen tongues were used in preparing this lot of dried tissue. The results are similiar to those obtained with pens 7 and 8. Pen 9 contained one of the very resistant types of birds, No. 79, which materially lengthened the survival period of the pen to 32 days, that of the three other birds in the pen being 24 days. If allowance is made for this bird, it appears that there was no material difference in the antineuritic values of the rations containing 15 and 25 per cent, respectively, of ox tongue. The details are shown in Table 3 and Figure 8.

TABLE 3.—*Experimental feeding of dried ox tongue and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 9.		*Days.*	*Per cent.*	
15 per cent ox tongue No. 611	77	18	−3.3	Polyneuritis.
Do	78	25	−21.3	Do.
Do	76	30	−9.6	Do.
Do	79	55	−34.2	Very thin, weak, end of test.
Average		32	−17.2	
PEN 10.				
25 per cent ox tongue No. 611	73	21	+5.9	Polyneuritis.
Do	74	21	+10.6	Do.
Do	75	25	−5.7	Do.
Do	72	49	−16.7	Do.
Average		29	−1.5	

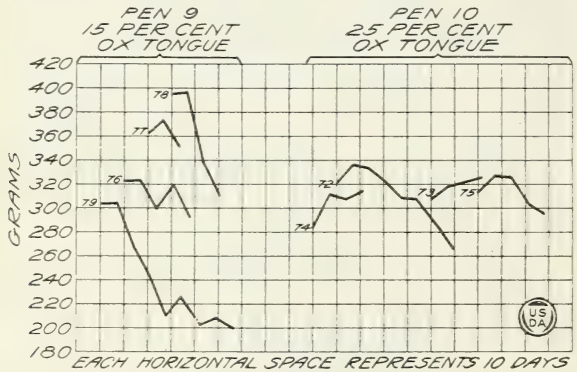

FIG. 8.—Dried ox tongue; changes in weights of pigeons fed.

Pens 11 to 14, inclusive, were fed muscle tissue derived from veal calves. The hind quarters from two carcasses of the best grade of medium-weight veal were used. The results from these tests are very similar to those obtained in feeding the same percentages of muscle from the mature ox. The average survival period of all the pigeons fed calf muscle was 27.9 days, while that of the birds receiving muscle from the mature ox was 26.6 days. The slight difference is not material. The results are shown in Table 4 and Figures 9 and 10.

TABLE 4.—*Experimental feeding of dried calf muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 11.				
		Days.	*Per cent.*	
15 per cent calf muscle No. 667	18	19	−18.0	Polyneuritis.
Do	19	19	−10.9	Do.
Do	17	20	−12.2	Died.
Do	20	21	−18.3	Polyneuritis.
Average		19.8	−14.9	
PEN 12.				
25 per cent calf muscle No. 667	23	18	−10.7	Polyneuritis.
Do	63	19	−20.8	Do.
Do	22	26	−26.8	Died.
Do	24	55	−20.3	Very thin, active, end of test.
Average		29.5	−19.7	
PEN 13.				
15 per cent calf muscle No. 725	98	23	−21.7	Polyneuritis
Do	203	24	−20.0	Do.
Do	204	30	−30.2	Do.
Do	56	47	−26.5	Do.
Average		31	−24.6	
PEN 14.				
25 per cent calf muscle No. 725	248	17	−2.7	Polyneuritis.
Do	282	28	+1.4	Do.
Do	270	32	−18.3	Do.
Do	274	49	−15.8	Severe keratomalacia.
Average		31.5	−8.9	

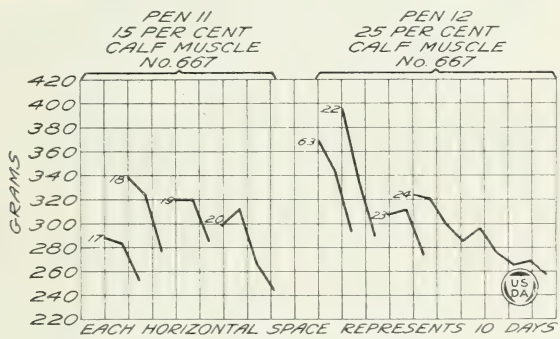

FIG. 9.—Dried calf muscle; changes in weights of pigeons fed.

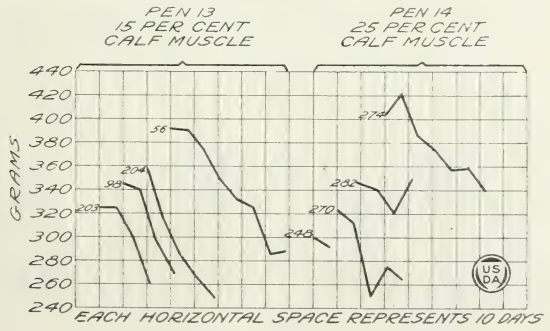

FIG. 10.—Dried calf muscle; changes in weights of pigeons fed.

FEEDING TESTS WITH SHEEP MUSCLE.

The results of the feeding test with sheep muscle are shown in Table 5. Each sample of muscle was derived from a single hind saddle of lamb, i. e., the two hind quarters. Sample 680 used in the rations fed to pens 15 and 16 represents a fairly fat, medium-weight carcass; sample 716 was taken from a light carcass of the same quality; while sample 719 represents an extra-fat, heavy-weight carcass of superior quality.

TABLE 5.—*Experimental feeding of dried sheep muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 15.		*Days.*	*Per cent.*	
15 per cent lamb muscle No. 680	50	15	−14.0	Polyneuritis.
Do	49	17	−20.9	Do.
Do	52	22	−16.7	Do.
Do	51	24	−22.3	Do.
Average		19.5	−18.5	
PEN 16.				
25 per cent lamb muscle No. 680	56	20	−5.1	Do.
Do	55	29	−20.8	Do.
Do	53	41	−33.2	Do.
Average		30	−19.7	
PEN 17.				
25 per cent lamb muscle No. 716	44	25	−17.7	Do.
Do	83	28	−20.1	Do.
Do	200	34	− 6.9	Do.
Do	6	47	−22.9	Very thin at close of test.
Average		33.5	−16.9	
PEN 18.				
25 per cent lamb muscle No. 719	30	32	+0.5	All birds in normal condition at close of test.
Do	97	32	+8.2	
Do	99	32	+5.1	
Average		32	+4.6	
PEN 19.				
15 per cent lamb tongue No. 619	62	18	−13.3	Polyneuritis.
Do	16	18	−11.9	Do.
Do	198	24	−20.3	Do.
Do	28	35	−12.4	Do.
Average		23.8	−14.5	
PEN 20.				
25 per cent lamb tongue No. 619	37	25	−9.9	Do.
Do	63	32	−4.9	Do.
Do	24	55	−7.6	Fair condition at close of test.
Do	61	55	−3.5	Do.
Average		41.8	−6.5	

The result of the test with pen 15 indicates that the ration containing 15 per cent of lamb muscle, No. 680, had a very low antineuritic value, about the same as that of the autoclaved polished rice fed to pens 2 and 3. The antineuritic value of the ration which contained 25 per cent of the same lot of lamb muscle was somewhat higher as measured by the survival periods of the two pens of birds, but the loss in weight was about the same.

Pen 17, getting a ration which contained 25 per cent of lamb muscle No. 716, yielded results very similar to those obtained with pen 16.

The results of the test with pen 18, which was fed a ration containing 25 per cent of lamb muscle No. 719, are of particular interest.

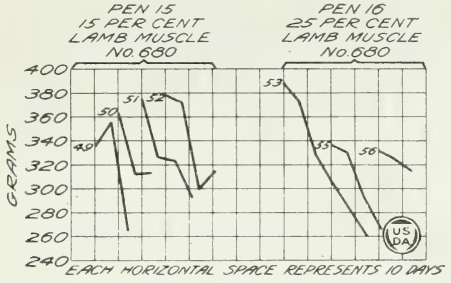

FIG. 11.—Dried lamb muscles; changes in weights of pigeons fed.

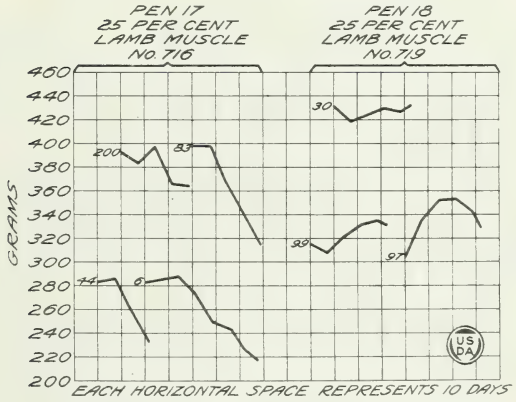

FIG. 12.—Dried lamb muscle; changes in weights of pigeons fed.

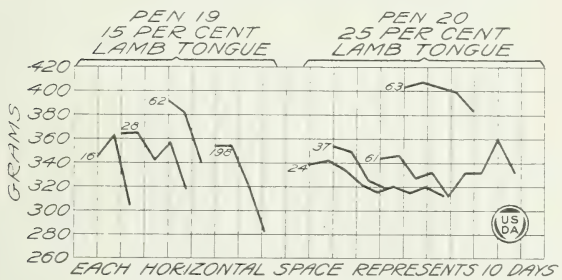

FIG. 13.—Dried lamb tongue; changes in weights of pigeons fed.

Not one of these pigeons developed polyneuritis, and all were in normal condition on the thirty-second day when the test was concluded because the supply of this lot of lamb muscle was exhausted. Although the survival period of this pen is recorded as 32 days, this value should not be compared with those of the other pens, since the

possible length of the test was 55 days. It has been observed that, as a rule, if pigeons maintain their weight and are in good condition after feeding 32 days on a ration, they will not develop the disease during an additional 23-day period. Each of the three pigeons in this pen gained in weight, the average being 4.6 per cent.

Pens 19 and 20 were fed rations which contained 15 and 25 per cent of lamb tongue No. 619. This sample was prepared from approximately 50 lamb tongues. The result obtained from pen 19 was about the same as that from pen 15, getting 15 per cent of lamb muscle No. 680, and indicates a low antineuritic value. Pen 20, getting 25 per cent of lamb tongue, yielded rather better results than pen 19, the survival period being 41.8 days as compared with 23.8, and the loss in weight only 6.5 per cent as compared with 14.5. Two birds in pen 20 were in fair condition at the close of the test, while all the pigeons in pen 19 had developed polyneuritis. The change in weights of the pigeons on the lamb-muscle rations are shown in Figures 11, 12, and 13.

TESTS WITH HOG MUSCLE.

RESULTS WITH UNCOOKED FRESH MUSCLE.

The feeding tests with hog muscle yielded the most interesting results of all of the experiments. The first lot of tenderloin, No. 681, which was purchased frozen, consisted of the tenderloin muscle from approximately 20 hogs. The results with uncooked fresh muscle are seen in Table 6 and Figures 14, 15, and 16.

In pen 21, pigeon 33 developed an infection of the eye early in the test and died on the forty-third day without any symptoms of polyneuritis. The data for this bird are excluded from the average for the pen. The three other birds were in good condition at the close of the test and each had gained in weight, the average being 3.1 per cent.

The birds in pen 22, on the ration containing 25 per cent of the same lot of tenderloin, were all in fine condition at the close of the test. One pigeon, No. 38, lost 3.2 per cent in weight, but by referring to Figure 14 it will be noted this bird was gaining in weight after an earlier loss. The average gain in weight for the pen was 7.1 per cent.

Pens 23 and 24 were fed rations containing 15 and 25 per cent of muscle obtained from four fresh pork hams representing the same number of hogs. The hams weighed from 8 to 10 pounds each. Every pigeon in each of these pens was in fine condition at the close of the test and each had gained very considerably in weight, the gains ranging from 10 to 20.6 per cent. The average gain for pen 23 was 13.6 per cent and for pen 24 it was 16.8 per cent.

Pens 25 and 26 were fed rations containing 15 and 25 per cent of another lot of frozen pork tenderloin, No. 702. Every bird but one in these pens was in fine condition at the close of the test and had gained in weight from 5.2 to 14.8 per cent. The one bird, No. 183, was in fair condition and had lost only 1.6 per cent in weight. The average gain in weight for each of the two pens was 10.1 and 11.0 per cent, respectively.

TABLE 6.—*Experimental feeding of dried uncooked hog muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 21.		*Days.*	*Per cent.*	
15 per cent tenderloin No. 681	[1] 33	43	−11.7	Died.
Do	34	55	+3.9	Good condition at close of test.
Do	35	55	+2.4	Do.
Do	36	55	+3.0	Do.
Average		55	+3.1	
PEN 22.				
25 per cent tenderloin No. 681	37	55	+11.8	Fine condition at close of test.
Do	38	55	−3.2	Do.
Do	39	55	+15.8	Do.
Do	40	55	+4.0	Do.
Average		55	+7.1	
PEN 23.				
15 per cent fresh ham	83	55	+14.7	Do.
Do	200	55	+10.4	Do.
Do	55	55	+18.9	Do.
Do	30	55	+10.5	Do.
Average		55	+13.6	
PEN 24.				
25 per cent fresh ham	65	55	+19.9	Do.
Do	34	55	+20.6	Do.
Do	199	55	+10.0	Do.
Average		55	+16.8	
PEN 25.				
15 per cent tenderloin No. 702	165	55	+14.4	Do.
Do	193	55	+13.1	Do.
Do	58	55	+14.4	Do.
Do	183	55	−1.6	Fair condition at end of test.
Average		55	+10.1	
PEN 26.				
25 per cent tenderloin No. 702	93	55	+14.8	Fine condition at close of test.
Do	15	55	+15.0	Do.
Do	87	49	+5.2	Do.
Do	80	55	+9.1	Do.
Average		53.5	+11.0	

[1] Data for this bird excluded from average.

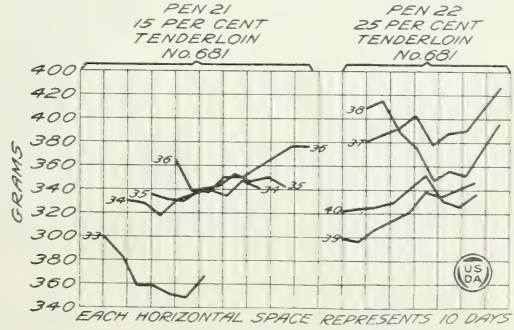

FIG. 14.—Dried hog muscle; changes in weights of pigeons fed.

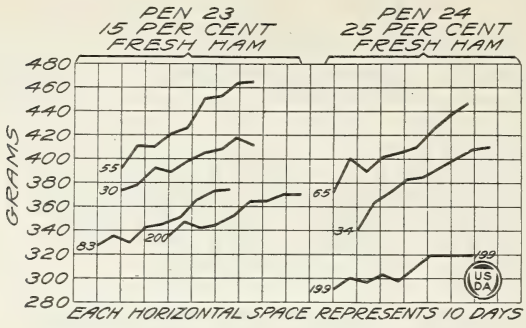

FIG. 15.—Dried hog muscle; changes in weights of pigeons fed.

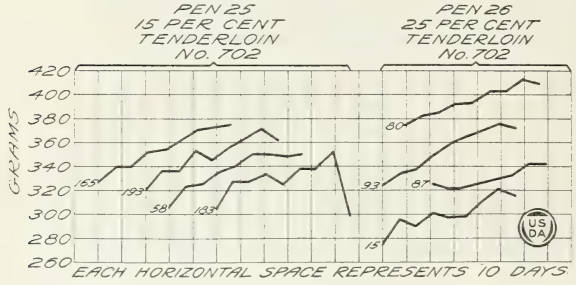

FIG. 16.—Dried hog muscle; changes in weights of pigeons fed.

RESULTS WITH UNCOOKED CURED, AND SMOKED MUSCLE.

Since most hams are not sold fresh, but are cured and smoked and sold as smoked hams, a feeding test was carried on with this class of hams in order to ascertain the effect of curing and smoking upon the antineuritic value of the product. Pens 27 and 28 were fed rations containing 15 and 25 per cent of muscle from two mild-cured smoked hams. Each and every bird in the two pens was in fine condition at the close of the test and had gained in weight; the gain for pen 27 was 6.3 per cent; that for pen 28 was 9.7 per cent. By referring to Table 6, pens 23 and 24, and to Table 7, pens 27 and 28, it will be noted that the antineuritic properties of the muscle from the fresh hams are very similar to those of the smoked hams. The birds getting the fresh-ham muscle made rather larger gains in weight, which indicates a slight advantage for the fresh hams.

Pens 29 and 30 were fed rations containing 15 and 25 per cent of muscle from hog tongues. The lot of muscle used represents approximately 50 hogs. One bird was removed from pen 29 early in the test on account of an injury to its neck; the three other birds were in good condition at the close of the test. The pen suffered a loss of 4.7 per cent in weight. The birds in pen 30 were all in fine condition at the close of the test and the average gain in weight was 9.6 per cent.

The results of this series are seen in Table 7, and the change in weights of the pigeons in pens 27 to 30, inclusive, is shown in Figures 17 and 18.

TABLE 7.—*Experimental feeding of dried, uncooked hog muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 27.				
		Days.	*Per cent.*	
15 per cent smoked ham	59	55	+5.3	Fine condition at close of test.
Do	45	55	+8.3	Do.
Do	58	55	+10.6	Do.
Do	88	55	+0.9	Do.
Average		55	+6.3	
PEN 28.				
25 per cent smoked ham	515	55	+12.4	Fine condition at close of test.
Do	130	55	+5.7	Do.
Do	56	55	+8.0	Do.
Do	176	55	+12.7	Do.
Average		55	+9.7	
PEN 29.				
15 per cent hog tongue	84	55	−1.7	Good condition at close of test.
Do	86	55	+0.6	Do.
Do	87	55	−12.9	Do.
Average		55	−4.7	
PEN 30.				
25 per cent hog tongue	80	55	+12.3	Fine condition at close of test.
Do	81	55	+17.3	Do.
Do	82	55	+10.1	Do.
Do	83	55	−1.3	Do.
Average		55	+9.6	

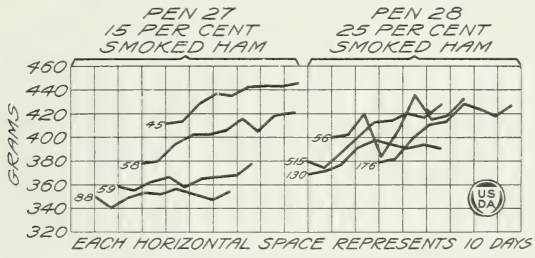

FIG. 17.—Dried smoked ham; changes in weights of pigeons fed.

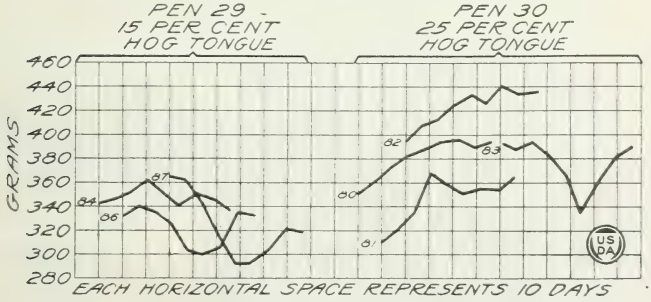

FIG. 18.—Dried hog tongue; changes in weights of pigeons fed.

THE EFFECT OF COOKING UPON THE ANTINEURITIC PROPERTIES OF HOG MUSCLE.

Since but very little pork is eaten in raw condition in this country, it is important to know the effect of cooking upon the antineuritic properties of hog muscle. Two experiments were carried on, one with tenderloin, the other with ham. The pork tenderloins, which weighed about one-fourth pound each, were baked 40 minutes at 200° C. in an oven. The meat was cooked just right for serving and then ground and dried in the usual manner. The cooked ham used in the feeding tests was the boneless, pressed ham of the kind which is sold sliced in retail markets. The method followed in cooking this type of hams is as follows: The cured hams are boned out, trimmed free of excess fat, and placed in metal containers in which they are pressed into the desired shape by means of a hydraulic press. The

TABLE 8.—*Experimental feeding of dried cooked hog muscle and polished rice.*

Meat ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 31.				
		Days.	*Per cent.*	
15 per cent baked tenderloin No. 722.	[1] 45	42	+7.1	Fine condition at end of test.
Do.	51	55	+15.0	Do.
Do.	59	55	+13.2	Do.
Do.	188	55	+4.1	Do.
Average.	.....	55	+9.9	
PEN 32.				
25 per cent baked tenderloin No. 722.	15	55	+14.1	Do.
Do.	30	55	+11.0	Do.
Do.	56	55	+11.8	Do.
Do.	176	55	+14.5	Do.
Average.	.....	55	+12.9	
PEN 33.				
15 per cent cooked ham No. 721.	[2] 58	35	+8.8	Removed, account injury.
Do.	65	55	+1.0	Fine condition at close of test.
Do.	193	55	+4.5	Do.
Do.	839	55	−1.0	Do.
Average.	.....	55	+1.5	
PEN 34.				
25 per cent cooked ham No. 721.	207	55	+10.5	Do.
Do.	2,193	55	+6.1	Do.
Do.	287	55	+.3	Do.
Average.	.....	55	+5.6	

[1] This pigeon substituted for an injured bird on thirteenth day.
[2] Data for this bird excluded from average.

hams, still in the containers, are then deposited in a cabinet-shaped steam cooker, where they are cooked for from 7 to 8½ hours by means of steam at a temperature of approximately 150° F., never higher than 160° F. At the end of the period the hams are chilled in a spray of cold water.

The results of feeding the cooked muscle are shown in Table 8, and the change in weight of the birds in Figures 19 and 20.

Pens 31 and 32 were fed rations containing 15 and 25 per cent of cooked tenderloin. At the end of the test not a bird in either pen had developed polyneuritis and all had gained in weight and were in better condition than at the start. These results are equally as

favorable as those secured in feeding the two lots of uncooked tenderloin, as shown in Table 6. Pens 33 and 34 were fed rations containing 15 and 25 per cent of cooked ham. One bird, No. 58, in pen 33 was removed on the thirty-fifth day on account of an injury, but it had gained 8.8 per cent in weight at the time. The other birds were in fine condition at the end of the test. The average gain in weight was 1.5 per cent. The birds in pen 34 were in fine condition at the close of the test and the average gain in weight was 5.6 per cent. By referring to Table 6, it will be noted that the average gains in weight of pens 23 and 24, respectively, getting raw ham, were somewhat higher than those of pens 33 and 34 which were fed corresponding percentages of cooked ham. This indicates a slightly lower antineuritic value for the cooked ham.

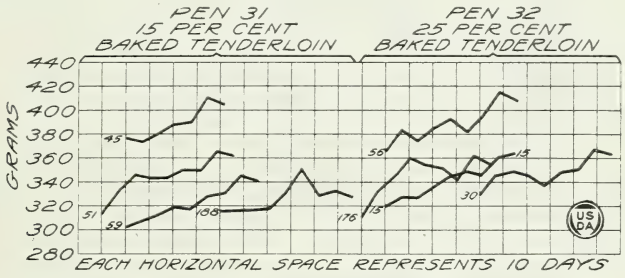

FIG. 19.—Dried hog muscle, cooked; changes in weights of pigeons fed.

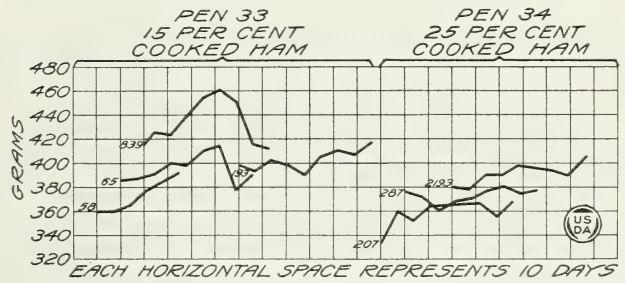

FIG. 20.—Dried ham, cooked; changes in weights of pigeons fed.

DISCUSSION OF RESULTS.

Since the identity of the antineuritic vitamin and the B-growth vitamin, though highly probable, is not yet proved, information on the subject is of interest. In the experiments which are reported in this paper it has been noted that, as a rule, though with a few exceptions, a marked decline in weight precedes the development of polyneuritis. Occasionally, however, a pigeon will lose over a third of its initial weight without developing the disease; on the other hand, if a bird maintains its weight, it is only rarely that it develops polyneuritis. These relations may be clearly seen by comparing the charts and tables in Part I of this paper. These facts are simply another indication of the close relationship that is known to exist between the antineuritic and the B-growth vitamins.

The wide difference which was found in the antineuritic properties of the ox and sheep muscle on the one hand and the hog muscle on the

other is surprising. The most reasonable explanation is that this variation is due to a difference in the antineuritic properties of the rations fed to the animals. This view is supported by the work of various investigators who have studied the effect of the character of the ration upon the vitamin content of milk—Dutcher and associates (*11*) (1920); Drummond and associates (*12*) (*13*) (1920) (1921); and Kennedy and Dutcher (*14*) (1922). Unfortunately we have no data as to the effect of the character of the feed consumed upon the antineuritic properties of the muscle of either the ox, sheep, or hog. It is possible, also, that the hog may have the peculiar function of storing up a larger proportion of the vitamin in its tissues than do the other animals named.

It is hardly necessary to state that, while the experiments which have been reported in this paper indicate that ox muscle has a much lower antineuritic value than hog muscle, it, of course, does not follow that beef has a low nutritive value. Rather, meat has a high nutritive value regardless of its vitamin content, and the presence of one or more of the vitamins in considerable quantities simply enhances the value of meat as a food. Naturally, if meat were the sole source of vitamin B in the diet, or even the most important source, then pork would be preferred to beef; on the other hand, if an ample supply of the B vitamin is furnished by other foods, then the relative antineuritic properties of beef, pork, and mutton become a matter of minor importance.

SUMMARY OF PART I.

The results of experiments to determine the antineuritic values of ox, hog, and sheep muscle when fed to pigeons may be summarized as follows:

1. *Ox muscle (mature ox).*—The samples of ox muscle examined had relatively low antineuritic values when used in rations to the extent of 25 per cent. This percentage would correspond to 3.75 grams of the dried tissue in the daily ration of a pigeon weighing 300 grams.

2. *Ox muscle (calf).*—The average antineuritic value of the samples tested was practically the same as the average value of the samples from the mature ox.

3. *Sheep muscle (lamb).*—Two samples of muscle had relatively low antineuritic values; one had a fair value (tongue); and the fourth had a reasonably high value, 25 per cent of the dried muscle in the ration protecting a pen of pigeons against polyneuritis and loss in weight during a period of 32 days.

4. *Hog muscle.*—The antineuritic values of the samples of uncooked hog muscle tested were very much higher than those of the ox or sheep muscle. Fifteen per cent of each of the samples tested was sufficient in a ration to protect a pen of pigeons against polyneuritis for a period of 55 days, and in only one instance did a pen of the birds lose slightly in weight, the other pens gaining from 3.1 to 16.8 per cent.

5. *Effect of cooking upon the antineuritic value of hog muscle.*—Baked tenderloin had practically the same value as the uncooked muscle, but cooked ham had a slightly lower value than the raw product. However, 15 per cent of cooked ham in a ration protected a pen of pigeons against polyneuritis and loss in weight during a period of 55 days.

II. VITAMIN B IN THE EDIBLE VISCERA OF THE OX, SHEEP, AND HOG.

IMPORTANCE OF EDIBLE VISCERA AS FOOD.

In the commercial slaughter of cattle, sheep, and hogs in this country, practically every edible part of the animal for which there is a market is saved for food purposes. The dressed carcass, of course, represents the largest proportion of the total food value of the animal; but the edible by-products, in packing-house parlance called "edible offal," are an important source of food. The edible viscera, or internal organs, make up the bulk of the edible by-products. In addition to their other nutritive properties, it has been observed that several of the internal organs are rich in vitamins.

In Tables 9 to 12, inclusive, which follow, are shown the yields of blood and edible viscera obtained in the commercial slaughter of several grades of cattle, sheep, and hogs.[1] Potentially, all the products named are available as food, but in practice some of them are saved only in limited quantities on account of the restricted demand for the same, or because it is not profitable to save them. Also there must be deducted from the total yields of the products named those products which have been condemned as unfit for food in accordance with the meat-inspection law. However, even after such corrections have been made, the quantity of edible viscera and blood saved for food purposes represents a very material percentage of the dressed weight of the ox, the sheep, and the hog.

TABLE 9.—*Average yield of edible viscera and blood from cattle.*

Item.	Canner cows, 128 head.		Medium steers, 71 head.		Prime steers, 65 head.	
	Average weight.	Per cent of dressed weight.	Average weight.	Per cent of dressed weight.	Average weight.	Per cent of dressed weight.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Average live weight	805.0	.....	1,134.0	.....	1,375.0	.....
Average dressed weight (chilled)	382.0	.....	640.0	.....	801.0	.....
Blood	30.0	7.85	55.0	8.59	80.0	9.99
Liver	9.0	2.35	10.0	1.56	14.3	1.79
Heart	2.8	.73	3.8	.59	4.4	.55
Lungs	6.0	1.57	6.7	1.05	7.0	.87
Spleen	2.0	.52	2.2	.34	2.2	.27
Kidneys	2.0	.52	2.3	.36	2.5	.31
Stomach (edible part)	15.5	4.06	19.0	2.97	19.0	2.37
Brains	.8	.21	1.0	.16	1.0	.12
Tongue (trimmed)	3.4	.89	4.5	.70	5.8	.72
Pancreas	.....	.....	1.2	.19	1.3	.16
Thymus	.....	.....	.3	.05	.3	.04
Total viscera and blood	71.5	18.70	106.0	16.56	137.8	17.19

[1] The data from which these tables have been prepared were kindly furnished by one of the large meat-packing establishments located in Chicago.

TABLE 10.—*Average yield of edible viscera and blood from calves.*

Item.	1 lot of 33 calves.		1 lot of 20 calves.	
	Average weight.	Per cent of dressed weight.	Average weight.	Per cent of dressed weight.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*
Average live weight	137.00	.....	240.00	.....
Average dressed weight	95.00	.....	155.00	.....
Blood	5.50	5.79	6.60	4.26
Liver	2.70	2.84	3.60	2.32
Heart	1.00	1.05	1.30	.83
Lungs	2.00	2.10	2.90	1.87
Spleen	.50	.53	.70	.45
Kidneys	.60	.63	1.20	.77
Stomach	3.00	3.15	6.60	4.26
Brains	.50	.53	.60	.39
Tongue	1.10	1.16	1.70	1.10
Thymus	.50	.53	.60	.39
Pancreas	.05	.05	.06	.04
Total viscera and blood	17.45	18.36	25.86	16.68

TABLE 11.—*Average yield of edible viscera and blood from sheep.*

Item.	1 lot of 20 sheep.		1 lot of 20 sheep.		1 lot of 20 sheep.	
	Average weight.	Per cent of dressed weight.	Average weight.	Per cent of dressed weight.	Average weight.	Per cent of dressed weight.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Average live weight	83.00	.....	99.00	.....	111.00	.....
Average dressed weight	38.10	.....	52.10	.....	57.00	.....
Blood	3.20	8.40	3.80	7.29	4.50	7.89
Liver	1.30	3.41	1.40	2.69	1.80	3.16
Heart	.40	1.05	.40	.77	.50	.88
Lungs	1.10	2.89	1.20	2.30	1.10	1.93
Spleen	.20	.53	.20	.38	.20	.35
Kidneys	.20	.53	.20	.38	.20	.35
Stomach	3.50	9.19	3.90	7.48	4.50	7.89
Brains	.20	.53	.20	.38	.30	.53
Tongue	.40	1.05	.50	.96	.50	.88
Thymus	.06	.16	.07	.13	.....	.....
Total viscera and blood	10.56	27.74	11.87	22.76	13.60	23.86

TABLE 12.—*Average yield of edible viscera and blood from hogs.*

Item.	Average of several tests.		Average of several tests.		Average of several tests.	
	Weight.	Per cent of dressed weight.	Weight.	Per cent of dressed weight.	Weight.	Per cent of dressed weight.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Average live weight	200.0	.....	300.0	.....	400.0	.....
Average dressed weight	148.0	.....	228.0	.....	308.0	.....
Blood	6.0	4.05	7.9	3.46	10.0	3.25
Liver	2.8	1.89	3.5	1.53	4.0	1.30
Heart	.6	.41	.7	.31	.8	.26
Spleen	.2	.13	.5	.22	.5	.17
Kidneys	.4	.27	.5	.22	.8	.26
Stomach	1.1	.74	1.3	.57	1.8	.58
Brain	.3	.20	.3	.13	.3	.10
Tongue	.8	.54	1.0	.44	1.3	.42
Total viscera and blood	12.2	8.23	15.7	6.88	19.5	6.34

PREVIOUS INVESTIGATIONS WITH EDIBLE VISCERA.

Cooper (*6*) (*15*), (1912) (1914) studied the antineuritic properties of a number of animal tissues in feeding tests with pigeons. Ox liver had the highest value, the daily addition of 0.9 grams of the dry tissue to the ration of pigeons being sufficient to protect them against polyneuritis for 50 days. The following quantities of each of the other tissues tested had like values: Ox heart, 1.7 grams; ox cerebrum, 1.2 grams; ox cerebellum, 2.4 grams; and sheep cerebrum, 1.6 to 3 grams.

McCollum and Davis (*16*) (1915) report that the addition of dried pig heart or kidney to the "fat-free diet" of rats that were declining in weight greatly stimulated growth, the kidney having greater value than the heart.

Eddy (*17*) (1916) found that the water-soluble portion of an alcoholic extract of sheep pancreas was capable of inducing marked growth in rats that had previously been fed a vitamin-free diet.

Osborne and Mendel (*18*) (1918) studied the value of dried pig heart, liver, kidney, and brain in the diets of young rats as a source of vitamins A and B, as well as of protein. They found that 19 per cent of pig heart in the ration as the sole source of protein and vitamins A and B induced normal growth in rats. Similar results were obtained with a ration containing 22 per cent of pig kidney. Rats made normal growth on a ration that contained 32.5 per cent of pig brain as a source of vitamin B, vitamin A being supplied in the form of butterfat. Ten per cent of pig brain did not supply sufficient vitamin B for growth. Seven per cent of pig liver, in an otherwise adequate diet, did not furnish sufficient vitamin B for growth; but when 10 per cent of liver was added, satisfactory growth took place.

McCollum, Simmonds, and Parsons (*10*) (1921) found that 25 per cent of dried ox liver or of ox kidney in a ration furnished an ample supply of vitamins A and B for growth and reproduction in white rats. Rats receiving 20 per cent of ox kidney in the ration also grew and reproduced normally, but those getting 20 per cent of ox liver did not do so well. One lot of rats that was fed solely on dried ox blood declined rapidly in weight and at the end of two weeks the ration was changed to contain 50 per cent of dried ox muscle. The rats then grew at about half the normal rate.

EXPERIMENTAL WORK.

The method of procedure followed in these experiments was practically the same as that employed in the tests with muscle tissue described in Part I. The various tissues studied were obtained in fresh conditions from local meat-packing establishments and were dried in the manner previously described. The dry tissue was used in all tests and the polished rice was first ground and then heated four hours at 120° C. in an autoclave before being used in the rations.

TESTS WITH OX LIVER.

The results of the feeding tests with ox liver are presented in Table 13. Three pens of pigeons were fed rations which contained 5, 15, and 30 per cent, respectively, of ox liver. By comparing the survival

periods and the changes in weight of the three pens of pigeons, it is apparent that neither 5 nor 15 per cent of ox liver in the ration was sufficient to protect the birds against polyneuritis for any considerable time, but that 30 per cent of ox liver was sufficient to protect three pigeons for at least 105 days. Each of the three pigeons had gained in weight and was in fine condition at the close of the test, but the fourth bird getting the same ration developed polyneuritis on the ninety-third day. The changes in weight of the pigeons are shown in Figure 21.

TABLE 13.—*Experimental feeding of dried ox liver and polished rice.*

Liver ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 35.		*Days.*	*Per cent.*	
5 per cent ox liver	110	44	−15.3	Polyneuritis.
Do	114	39	−28.2	Do.
Do	115	45	−17.0	Do.
Do	117	40	−22.9	Do.
Average		42	−20.9	
PEN 36.				
15 per cent ox liver	116	55	−14.8	Fair condition at end of test.
Do	118	40	−10.8	Polyneuritis.
Do	119	37	−1.8	Do.
Do	121	45	−10.0	Do.
Average		44	− 9.4	
PEN 37.				
30 per cent ox liver	120	105	+19.3	Fine condition at end of test.
Do	123	105	+ 9.9	Do.
Do	124	105	+ 2.4	Do.
Do	214	93	− 1.3	Polyneuritis.
Average		102	+ 7.6	

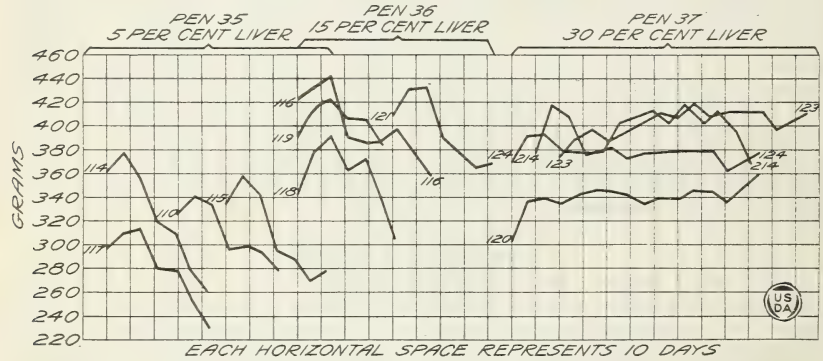

FIG. 21.—Dried ox liver; changes in weights of pigeons fed.

TESTS WITH CALF LIVER.

The results of the feeding tests with calf liver are shown in Table 14. Three pens of pigeons were fed rations which contained 5, 15, and 30 per cent, respectively, of calf liver. On taking into consideration both the survival periods of the pigeons and their changes in weights, it is evident that the ration which contained 5 per cent calf liver had the lowest antineuritic value, followed in turn by those containing 15 and 30 per cent of the tissue. The changes in the weights of the birds are seen in Figure 22.

TABLE 14.—*Experimental feeding of dried calf liver and polished rice.*

Liver ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 38.				
		Days.	*Per cent.*	
5 per cent calf liver	46	19	−28.1	Polyneuritis.
Do	52	50	−39.2	Very thin, end of test.
Do	57	50	−41.5	Do.
Average	.....	39.7	−36.3	
PEN 39.				
15 per cent calf liver	138	28	−7.8	Polyneuritis.
Do	140	74	−23.6	Do.
Do	141	65	−28.3	Do.
Do	[1] 143	48	−28.8	Died, pneumonia.
Average	.....	55.7	−19.9	
PEN 40.				
30 per cent calf liver	62	55	−13.7	Polyneuritis.
Do	65	55	+16.0	Do.
Do	139	65	−4.4	Do.
Do	145	89	−2.5	Do.
Average	.....	66	−1.2	

[1] Data for this pigeon excluded from average.

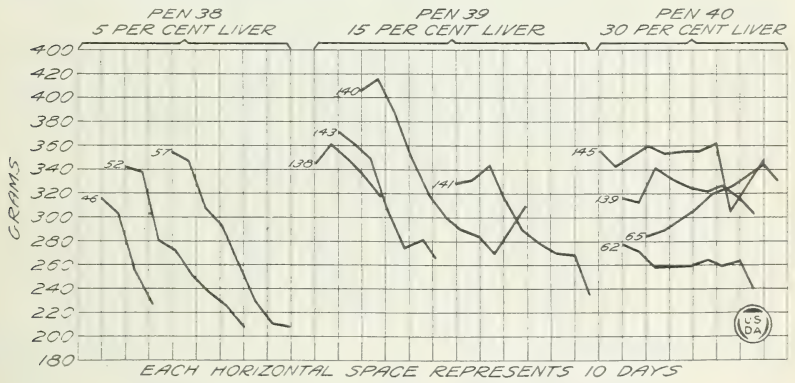

FIG. 22.—Dried calf liver; changes in weights of pigeons fed.

TESTS WITH LAMB LIVER AND HOG LIVER.

In Table 15 are presented the results of the feeding tests with lamb liver and hog liver. The ration containing 15 per cent of lamb liver had a very low antineuritic value, the average survival period of the pen of birds being only 21 days and the loss in weight 11.4 per cent. The ration which contained 25 per cent of lamb liver had a considerably higher antineuritic value, the survival period for the pen being 62 days out of a possible 70 days. One pigeon developed polyneuritis on the thirty-eighth day, one died from an injury on the sixty-eighth day, and the three other birds completed the test.

The results of the tests with hog liver were more favorable than those with lamb liver. The pen of pigeons getting 15 per cent of hog liver in their feed showed a survival period of 62 days out of a possible 70. One bird developed polyneuritis on the thirty-seventh

day, but the three others finished the test either in good or in fine condition. The pen showed a gain in weight of 4 per cent. The pigeons that were fed 25 per cent of hog liver in their ration all completed the 70-day test in fine condition with an average gain in weight of 12.1 per cent. Figures 23 and 24 show the changes in weights of the pigeons on the lamb-liver and hog-liver diets.

TABLE 15.—*Experimental feeding of dried lamb and hog liver with polished rice.*

Liver ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 41.		*Days.*	*Per cent.*	
15 per cent lamb liver	164	20	−14.3	Polyneuritis.
Do	165	22	−12.9	Do.
Do	166	16	−9.9	Do.
Do	167	24	−10.2	Do.
Do	168	24	−9.7	Do.
Average		21	−11.4	
PEN 42.				
25 per cent lamb liver	159	70	−2.3	Fine condition end of test.
Do	160	38	−12.8	Polyneuritis.
Do	161	70	+18.3	Fine condition end of test.
Do	162	70	−15.6	Fair condition end of test.
Do	[1] 163	68	−7.4	Died, injury.
Average		62	−3.1	
PEN 43.				
15 per cent hog liver	155	37	−3.6	Polyneuritis.
Do	156	70	−1.6	Good condition end of test.
Do	157	70	+9.8	Fine condition end of test.
Do	158	70	+11.3	Do.
Average		62	+4.0	
PEN 44.				
25 per cent hog liver	149	70	+16.2	Do.
Do	150	70	+8.4	Do.
Do	151	70	+14.8	Do.
Do	308	70	+8.8	Do.
Average		70	+12.1	

[1] Data for this pigeon excluded from average.

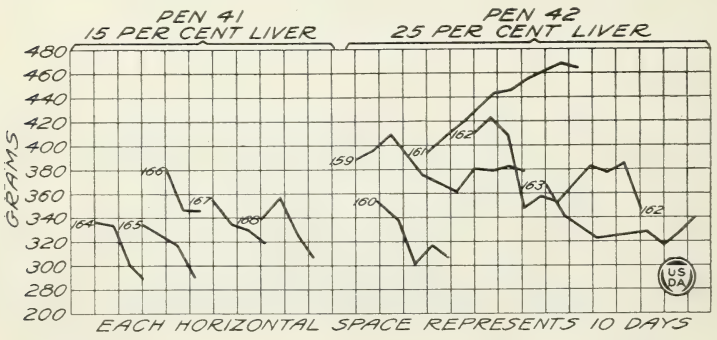

FIG. 23.—Dried lamb liver; changes in weights of pigeons fed.

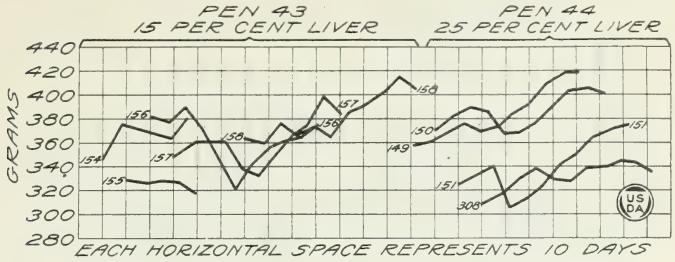

FIG. 24.—Dried hog liver; changes in weights of pigeons fed.

TESTS WITH OX HEART AND HOG HEART.

Four pens of pigeons of four birds each were fed rations containing 15 and 25 per cent of ox heart and of hog heart, respectively, during a period of 55 days. There was not a single case of polyneuritis and every bird had gained in weight, the percentages ranging from 2.7 to 21.1. The average gains for the pens of birds ranged from 6.9 to 14.3 per cent, the pigeons getting the ox-heart rations making slightly larger gains than the others. The high antineuritic value of ox heart and hog heart is evident. Figures 25 and 26 show the changes in the weights of the pigeons fed ox heart and hog heart.

TABLE 16.—*Experimental feeding of dried ox heart and hog heart with polished rice.*

Heart ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 45.				
		Days.	*Per cent.*	
15 per cent ox heart	19	55	+12.3	Fine condition end of test.
Do	20	55	+21.1	Do.
Do	21	55	+15.0	Do.
Do	22	55	+5.5	Good condition end of test.
Average	.....	55	+13.5	
PEN 46.				
25 per cent ox heart	15	55	+12.1	Fine condition end of test.
Do	16	55	+16.7	Do.
Do	17	55	+19.1	Do.
Do	18	55	+9.2	Do.
Average	.....	55	+14.3	
PEN 47.				
15 per cent hog heart	27	55	+4.6	Do.
Do	28	55	+10.3	Do.
Do	29	55	+9.8	Do.
Do	30	55	+2.7	Do.
Average	.....	55	+6.9	
PEN 48.				
25 per cent hog heart	23	55	+15.0	Do.
Do	24	55	+9.8	Do.
Do	25	55	+12.2	Do.
Do	26	55	+12.5	Do.
Average	.....	55	+12.4	

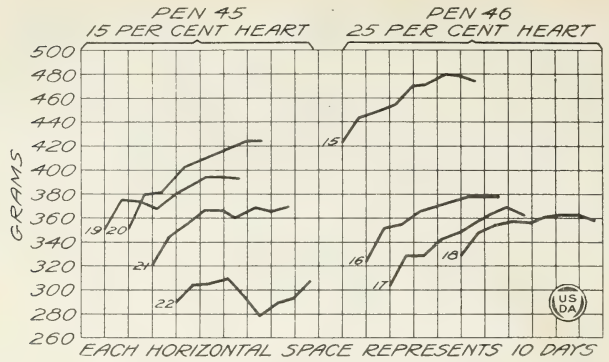

FIG. 25.—Dried ox heart; changes in weights of pigeons fed.

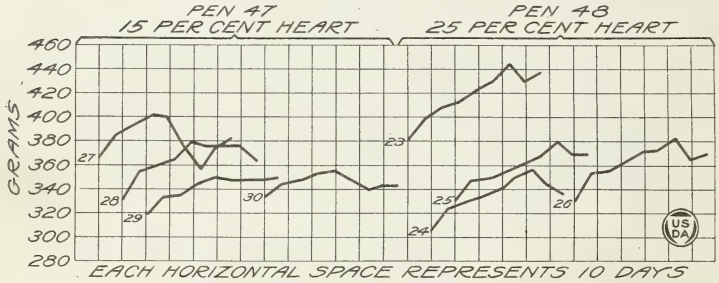

FIG. 26.—Dried hog heart; changes in weights of pigeons fed.

TESTS WITH LAMB HEART.

The results of the tests with lamb heart are presented in Table 17. None of the birds fed the ration which contained 15 per cent lamb heart developed polyneuritis during the test period of 63 days; one bird lost 7.4 per cent in weight, while the two others gained 3.7 and 2.7 per cent, respectively. Three pigeons were fed a ration containing 25 per cent lamb heart; one developed polyneuritis on the thirty-fourth day, even though it had gained 8.5 per cent in weight; the two other birds were in fine condition at the close of the test on the sixty-third day. Figure 27 shows the changes in weight of pigeons that were fed lamb heart.

TABLE 17.—*Experimental feeding of dried lamb heart and polished rice.*

Heart ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 49.		*Days.*	*Per cent.*	
15 per cent lamb heart	2	63	+3.7	Fine condition end of test.
Do	134	63	−7.4	Do.
Do	176	63	+2.7	Do.
Average	.....	63	−0.3	
PEN 50.				
25 per cent lamb heart	82	63	+17.5	Do.
Do	838	63	+10.5	Do.
Do	284	34	+8.5	Polyneuritis.
Average	.....	53	+12.2	

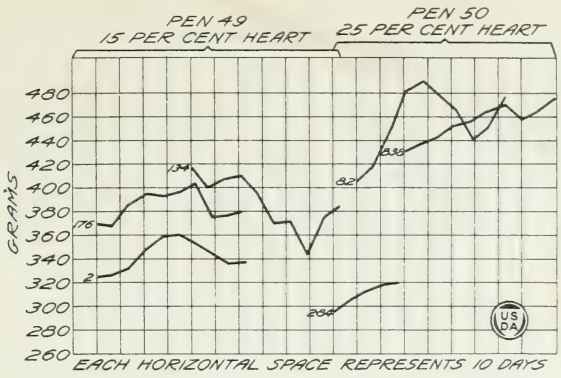

FIG. 27.—Dried lamb heart; changes in weights of pigeons fed.

TESTS WITH OX KIDNEY AND HOG KIDNEY.

The results of the feeding experiments with ox kidney and hog kidney are presented in Table 18. Fifteen per cent of ox kidney in a ration was sufficient to protect three pigeons against polyneuritis for a period of 63 days, and all the birds were in good condition at the close of the test. The average change in weight of the birds on this ration was a loss of 4 per cent. The ration containing 25 per cent of ox kidney also protected three pigeons against polyneuritis during a period of 63 days and the birds were in good condition at the close of the test. The average change in weight of the birds was a gain of 6.3 per cent. A fourth pigeon in the pen died on the fifty-first day from an unknown cause. It apparently was in normal condition on the previous day.

TABLE 18.—*Experimental feeding of dried ox and hog kidney with polished rice.*

Kidney ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 51.		*Days.*	*Per cent.*	
15 per cent ox kidney	28	63	−6.6	Good condition end of test.
Do	29	63	−0.9	Do.
Do	35	63	−4.5	Do.
Average		63	−4.0	
PEN 52.				
25 per cent ox kidney	24	63	+4.5	Do.
Do	25	63	+7.6	Do.
Do	26	63	+5.8	Do.
Do	[1] 27	51	+1.0	Died.
Average		63	+6.3	
PEN 53.				
15 per cent hog kidney	65	63	−3.6	Good condition end of test.
Do	66	63	−3.5	Do.
Do	67	63	+7.2	Do.
Average		63	+0.03	
PEN 54.				
25 per cent hog kidney	37	63	+7.8	Do.
Do	61	63	+11.5	Do.
Do	62	63	+2.6	Do.
Do	63	63	+13.6	Do.
Average		63	+8.9	

[1] Data for this pigeon excluded from average.

The rations containing 15 and 25 per cent, respectively, of hog kidney, each protected pigeons against polyneuritis for a period of 63 days and all the birds were in good condition at the end of the test. The birds getting the ration that contained 15 per cent hog kidney maintained their weight, and those getting 25 per cent hog kidney in their feed gained an average of 8.9 per cent. On comparing the results of the tests with ox kidney and hog kidney it appears that they have practically the same antineuritic value.

Figures 28 and 29 show the changes in the weights of the pigeons fed the ox- and hog-kidney rations.

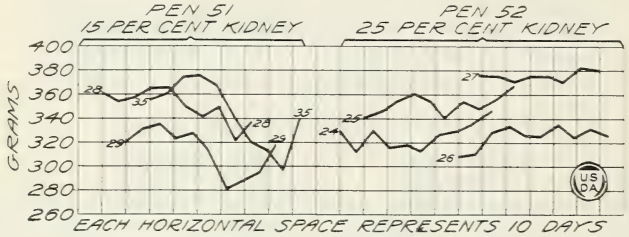

FIG. 28.—Dried ox kidney; changes in weights of pigeons fed.

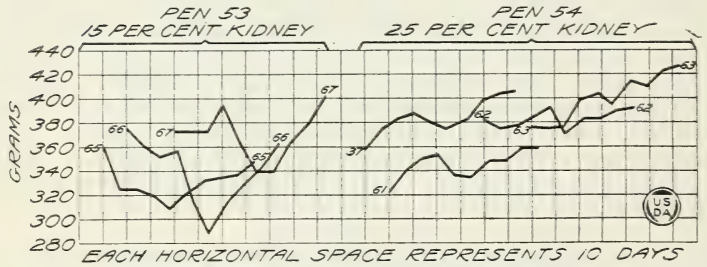

FIG. 29.—Dried hog kidney; changes in weights of pigeons fed.

TESTS WITH OX SPLEEN AND HOG SPLEEN.

In Table 19 are presented the results of the feeding tests with ox spleen and hog spleen. Fifteen per cent of ox spleen in a ration was sufficient to protect three out of four pigeons against polyneuritis during a test period of 57 days, but the fourth bird developed the disease on the fifty-second day. The average loss in weight of the birds was 13 per cent. Twenty-five per cent of ox spleen protected four pigeons for 57 days and the average loss in weight was 15.6 per cent.

The feeding tests with hog spleen yielded results very similar to those obtained with ox spleen. Fifteen per cent of hog spleen protected three pigeons against polyneuritis for 57 days, but one bird developed the disease on the forty-ninth day. Twenty-five per cent of hog spleen protected three pigeons for 57 days, but one bird, No. 67, was greatly emaciated at the close of the test. Another bird, No. 83, died on the forty-fourth day without having shown any characteristic symptoms of polyneuritis. Every pen of pigeons on the ox-spleen and hog-spleen diets lost considerably in weight, the percentages ranging from 13 to 20.4. Figures 30 and 31 show the changes in the weights of the pigeons fed the ox- and hog-spleen rations.

TABLE 19.—*Experimental feeding of dried ox spleen and hog spleen with polished rice.*

Spleen ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 55.		*Days.*	*Per cent.*	
15 per cent ox spleen	2	57	−23.4	Fair condition end of test.
Do	5	57	−5.0	Good condition end of test.
Do	42	52	−0.4	Polyneuritis.
Do	45	57	−23.0	Fair condition end of test.
Average		56	−13.0	
PEN 56.				
25 per cent ox spleen	64	57	−6.3	Fair condition end of test.
Do	74	57	−12.8	Do.
Do	77	57	−24.6	Do.
Do	99	57	−18.7	Do.
Average		57	−15.6	
PEN 57.				
15 per cent hog spleen	65	49	−12.0	Polyneuritis.
Do	66	57	−14.5	Fair condition end of test.
Do	68	57	−28.0	Poor condition end of test.
Do	71	51	−6.2	Fair condition end of test.
Average		55	−15.2	
PEN 58.				
25 per cent hog spleen	29	57	−0.6	Good condition end of test.
Do	35	57	−12.6	Fair condition end of test.
Do	67	57	−47.9	Very poor condition end of test.
Do	[1] 83	44	−17.0	Died.
Average		57	−20.4	

[1] Data for this bird excluded from average.

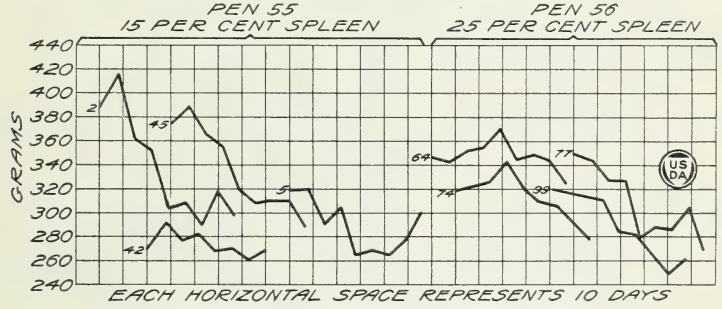

FIG. 30.—Dried ox spleen; changes in weights of pigeons fed.

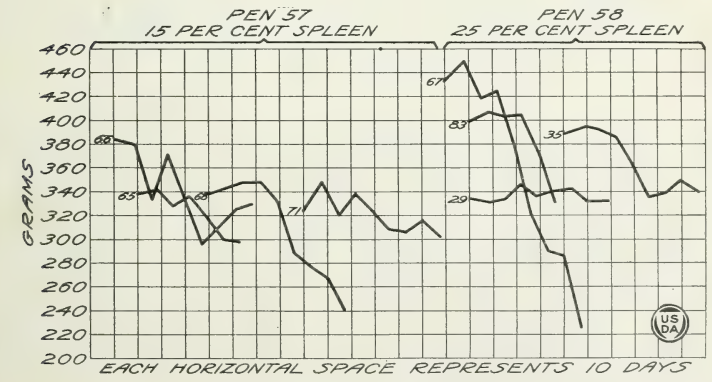

FIG. 31.—Dried hog spleen; changes in weights of pigeons fed.

THE EFFECT OF HEATING UPON THE ANTINEURITIC VALUE OF OX LIVER, HEART, AND KIDNEY.

Since liver, heart, and kidney are, of course, not used in a raw condition as human food, it is important to know the effect of cooking upon the antineuritic value of these tissues. In Table 20 are presented the results of feeding experiments with pigeons to test the effects of heating upon the antineuritic properties of ox liver. The changes in weight are shown in Figures 32 and 33.

TABLE 20.—*Effect of heating ox liver on its antineuritic value.*

Liver ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 59.				
		Days.	*Per cent.*	
30 per cent ox liver heated 2 hours at 100° C.	91	18	−18.5	Polyneuritis.
Do	92	20	−6.0	Died.
Do	93	20	−18.0	Polyneuritis.
Do	94	35	−17.9	Thin, active, end of test.
Average	.....	23	−15.1	
PEN 60.				
30 per cent ox liver heated 2 hours at 124° C. in autoclave	86	25	−16.8	Polyneuritis.
Do	88	23	−13.9	Do.
Do	89	17	−17.6	Do.
Do	556	24	−23.7	Do.
Average	.....	22	−18.0	
PEN 61.				
30 per cent ox liver heated 2 hours at 130° C. in autoclave	81	25	−24.3	Do.
Do	82	32	−34.7	Do.
Do	83	30	−44.9	Do.
Do	84	35	−27.7	Fair condition end of test.
Average	.....	31	−32.9	
PEN 62.				
25 per cent fried ox liver	169	70	−4.2	Do.
Do	170	43	−9.8	Polyneuritis.
Do	171	65	−25.4	Do.
Do	172	48	−2.9	Do.
Do	173	70	−1.5	Fair condition end of test.
Average	.....	59	−11.0	
PEN 63.				
25 per cent ox liver baked 30 minutes at 186° C.	4	42	−12.1	Polyneuritis.
Do	5	55	+3.7	Fine condition end of test.
Do	6	55	+1.6	Do.
Average	.....	51	−2.3	

Pen 59 was fed a ration which contained 30 per cent of liver that had been heated two hours in live steam at 100° C. The liver was first dried in the usual way and then spread out in a thin layer in pans and heated in an Arnold sterilizer for two hours and again dried. The result of the feeding test with the ration containing 30 per cent of this lot of liver indicates that the antineuritic value of the tissue had been largely destroyed. One pigeon developed polyneuritis on the eighteenth day, another on the twentieth day, a third died on the same day without positive symptoms of polyneuritis, while the fourth bird was in fair condition on the thirty-fifth day when the test was concluded.

Pen 60 was fed a ration containing 30 per cent of ox liver that had been heated two hours in an autoclave at 124° C. The previously dried liver was spread out in a thin layer in pans and heated in an autoclave under the conditions stated, and then dried in the usual way. The result of the feeding test with this lot of liver indicated that the antineuritic properties of the tissue had been practically destroyed. The four pigeons on this ration developed polyneuritis on the seventeenth, twenty-third, twenty-fourth, and twenty-fifth days, respectively. The average survival period was 22 days, and the average loss in weight was 18 per cent.

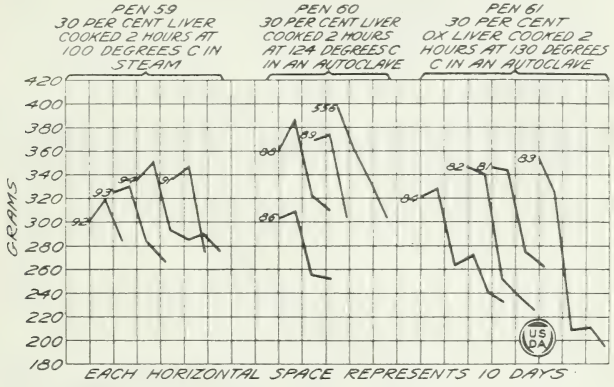

FIG. 32.—Cooked ox liver; changes in weights of pigeons fed.

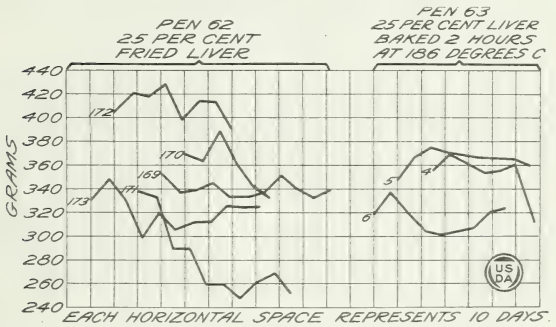

FIG. 33.—Fried and baked ox liver; changes in weights of pigeons fed.

Pen 61 was fed a ration which contained 30 per cent of ox liver that had been heated 2 hours at 130° C. in an autoclave. The antineuritic properties of this lot of liver were largely destroyed by the method of cooking used.

Pen 62 was fed a ration containing 25 per cent of ox liver that had been fried in the manner customary in its preparation for the table. The fried liver was ground and dried. This pen of pigeons was fed for a period of 70 days and the average survival period was 59 days. Three pigeons developed polyneuritis on the forty-third, forty-eighth, and sixty-fifth days, respectively, while two birds finished the test in fair condition. By comparing the results obtained from this pen of

birds with those from pens 59 to 61, inclusive, it is apparent that frying caused a much smaller destruction of the antineuritic vitamin in ox liver than the other methods of heating. By comparing the results obtained from pen 62, Table 20, with those from pen 37, Table 13, it appears that the fried liver had an appreciably lower antineuritic value than the uncooked product.

Pen 63 was fed a ration which contained 25 per cent of ox liver that had been baked 30 minutes in an oven at 186° C. The liver was sliced as for frying and then baked in a gas oven until cooked through. The cooked liver was ground and dried. One bird in this pen developed polyneuritis on the forty-second day, but the other two were in good condition on the fifty-fifth day when the test was concluded. The baked liver appeared to have practically the same antineuritic value as the fried product.

The effect of cooking on the antineuritic values of ox heart and kidney is shown in Table 21, and the changes in the weights of the pigeons fed are seen in Figure 34. The heart was washed free of blood and then cooked in boiling water for 75 minutes and finally baked for

TABLE 21.—*Effect of cooking upon the antineuritic value of ox heart and kidney.*

Heart and kidney rations.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 64.				
		Days.	*Per cent.*	
15 per cent cooked ox heart	68	59	− 3.2	Good condition end of test.
Do	69	37	−18.0	Polyneuritis.
Do	70	22	−12.1	Do.
Do	71	59	+ 1.9	Good condition end of test.
Average		44	− 7.9	
PEN 65.				
15 per cent cooked ox kidney	41	20	− 4.6	Polyneuritis.
Do	42	50	−21.7	Do.
Do	43	24	−12.3	Do.
Do	44	56	−31.3	Very thin end of test.
Average		38	−17.5	
PEN 66.				
25 per cent cooked ox kidney	45	54	−10.0	Polyneuritis.
Do	46	56	−18.8	Fair condition end of test.
Do	47	56	−16.0	Do.
Do	48	56	− 7.2	Do.
Average		56	−13.0	

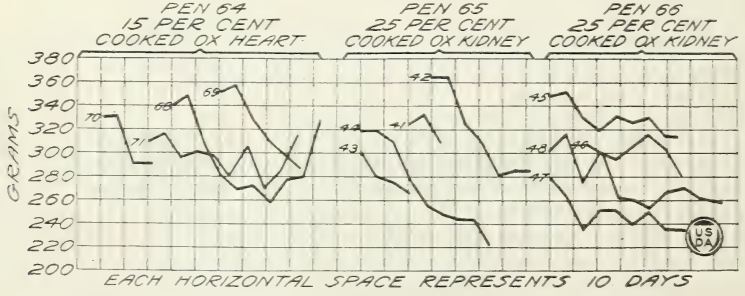

FIG. 34.—Cooked ox heart and ox kidney; changes in weights of pigeons fed.

40 minutes at 210°–220° C. The cooked heart was then ground and dried. Pen 64 was fed a ration containing 15 per cent of the cooked ox heart. Two pigeons developed polyneuritis, one on the twenty-second day, the other on the thirty-seventh day, and the other two birds were in good condition at the close of the test on the fifty-ninth day. By comparing the result of this test with that secured from feeding the ration that contained 15 per cent of uncooked ox heart, pen 45, Table 16, it is evident that the method employed in cooking the ox heart materially lowered its antineuritic value.

The ox kidney was cooked in the following manner: The fresh kidneys were split open, trimmed as free as practicable from fat and connective tissue, cut into small cubes, and then washed thoroughly in cold water. The kidney was then placed in a kettle, covered with water, and heated to boiling. The water was poured off, fresh water was added, and boiling was continued for an hour when the kidney was sufficiently tender to eat. The water was poured off and the cooked kidney was ground and dried is the usual manner. Pens 65 and 66 were fed rations which contained 15 and 25 per cent, respectively, of the cooked ox kidney. The ration containing 15 per cent of the cooked ox kidney had a rather low antineuritic value. Three pigeons developed polyneuritis on the twentieth, twenty-fourth, and fiftieth days, respectively, and one bird was in very poor condition at the close of the test on the fifty-sixth day. The ration that contained 25 per cent of the cooked kidney had a fair antineuritic value. One pigeon developed polyneuritis on the fifty-fourth day; the three others were in fair condition at the close of the test on the fifty-sixth day. The pen of birds suffered an average loss in weight of 13 per cent, which is an indication of a deficiency of the antineuritic vitamin in the ration.

TESTS WITH OX BRAINS AND LAMB BRAINS.

The results of the feeding test with ox and lamb brains are reported in Table 22. The ration containing 15 per cent of ox brains had a very low antineuritic value, three of the birds having developed polyneuritis by the nineteenth day and the fourth bird was in poor condition at the close of the test period of 55 days. The average survival period was 26 days and the loss in weight 9.7 per cent. The ration which contained 25 per cent of ox brains had a fair antineuritic value, the average survival period being 41 days and the loss in weight 6.7 per cent. Two birds developed polyneuritis on the twenty-fifth and thirtieth days, respectively; the other two were in good condition at the close of the test.

Lamb brains had practically the same antineuritic value as ox brains. One bird in pen 70 died on the twenty-second day of the test on account of an injury. The changes in the weights of the pigeons getting the ox-and-lamb brains ration are shown in Figures 35 and 36.

TABLE 22.—*Experimental feeding of dried ox brains and lamb brains with polished rice.*

Brain ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 67.		*Days.*	*Per cent.*	
15 per cent ox brains	39	13	−9.7	Polyneuritis.
Do	40	16	−13.4	Do.
Do	41	55	−13.7	Poor condition end of test.
Do	42	19	−2.1	Polyneuritis.
Average		26	−9.7	
PEN 68.				
25 per cent ox brains	35	55	−9.3	Good condition end of test.
Do	36	30	−12.5	Polyneuritis.
Do	37	55	−3.6	Good condition end of test.
Do	38	25	−1.4	Polyneuritis.
Average		41	−6.7	
PEN 69.				
15 per cent lamb brains	20	26	−6.6	Do.
Do	21	15	−4.0	Do.
Do	22	41	−11.0	Do.
Do	[1] 23	35	−29.6	Died.
Average		29	−12.8	
PEN 70.				
25 per cent lamb brains	16	55	+0.9	Good condition end of test.
Do	17	25	−11.8	Polyneuritis.
Do	18	55	+4.8	Good condition end of test.
	[1] 19	22	+0.8	Died account injury.
Average		45	−2.0	

[1] Results from this bird excluded from average.

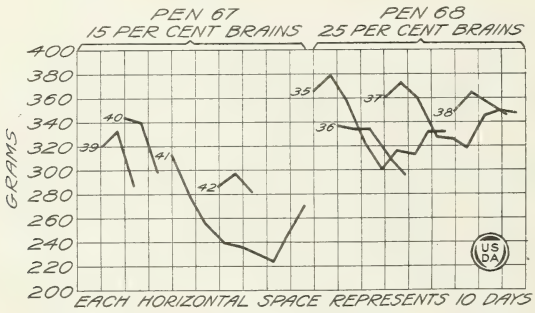

FIG. 35—Dried ox brains; changes in weights of pigeons fed.

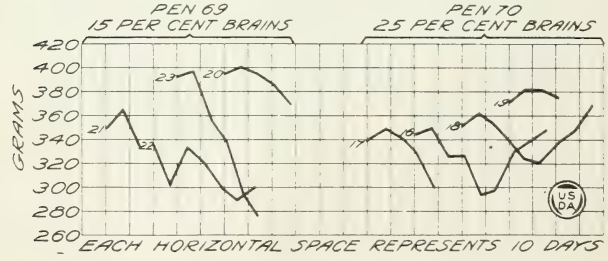

FIG. 36—Dried lamb brains; changes in weights of pigeons fed.

TESTS WITH OX LUNGS AND LAMB LUNGS.

In Table 23 are presented the results of the feeding tests with ox lungs and lamb lungs. The ox lungs appeared to have a fair antineuritic value. Two of the pigeons which were fed the ration containing 15 per cent of ox lungs were in good condition at the close of the test; one bird developed polyneuritis on the forty-second day; and the other died at the same time. The ration containing 25 per cent of ox lungs had a somewhat higher antineuritic value. Two of the pigeons were in good condition and two were in fair condition at the close of the test.

TABLE 23.—*Experimental feeding of dried ox lungs and lamb lungs with polished rice.*

Lung ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 71.		*Days.*	*Per cent.*	
15 per cent ox lungs	6	55	−5.9	Good condition end of test.
Do	22	42	−13.1	Polyneuritis.
Do	34	55	−9.0	Good condition end of test.
Do	72	42	−17.4	Died.
Average		49	−11.4	
PEN 72.				
25 per cent ox lungs	21	55	−15.1	Good condition end of test.
Do	85	55	−26.4	Fair condition end of test.
Do	92	55	−16.3	Good condition end of test.
Do	95	55	−18.8	Fair condition end of test.
Average		55	−19.2	
PEN 73.				
15 per cent lamb lungs	50	33	−18.3	Polyneuritis.
Do	51	55	−20.9	Very thin end of test.
Do	57	21	−2.6	Removed account extreme weakness.
Do	59	21	−6.3	Polyneuritis.
Average		33	−12.0	
PEN 74.				
25 per cent lamb lungs	52	50	−27.2	Died.
Do	54	55	−12.0	Poor condition end of test.
Do	55	55	−14.6	Do.
Do	100	45	−31.3	Died.
Average		51	−21.3	

Lamb lungs appeared to have a rather lower antineuritic value than the ox lungs tested. The ration containing 15 per cent of lamb lungs protected four pigeons against polyneuritis for an average period of only 33 days, and the ration which contained 25 per cent of the tissue protected four birds for an average period of 51 days. Two birds getting the latter ration died of inanition on the forty-fifth and fiftieth days, respectively, after having suffered severe losses in weight, but without showing any characteristic symptoms of polyneuritis. The two surviving birds were in poor condition at the close of the test.

The changes in the weights of the pigeons during the test are shown in Figures 37 and 38.

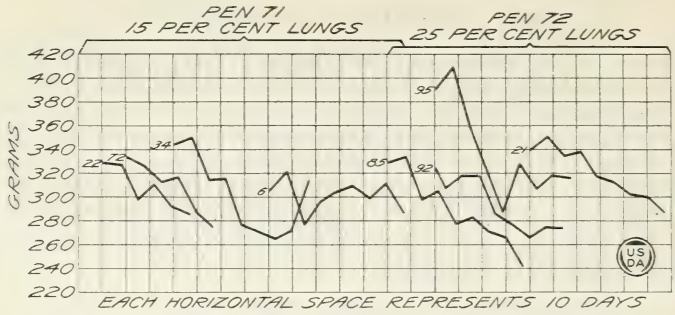

FIG. 37—Dried ox lungs; changes in weights of pigeons fed.

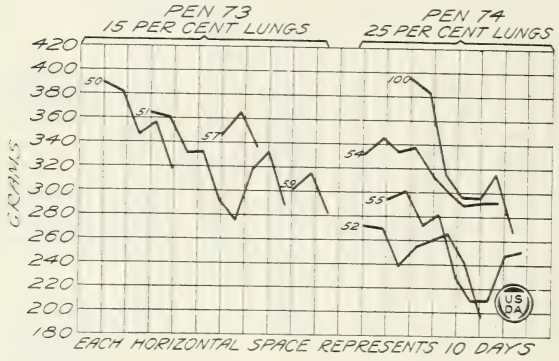

FIG. 38—Dried lamb lungs; changes in weights of pigeons fed.

TESTS WITH CALF PANCREAS AND HOG PANCREAS.

In Table 24 are presented the results of the feeding tests with calf pancreas and hog pancreas. Calf pancreas appears to have a rather low antineuritic value. The rations containing 15 and 25 per cent, respectively, of the tissue had practically the same value, the average survival period and the loss in weight being practically the same for the two pens of pigeons getting these rations.

Hog pancreas appears to have a slightly higher antineuritic value than calf pancreas. The pigeons that were fed the ration containing 15 per cent of hog pancreas showed an average survival period of 29 days and a loss in weight of 23.2 per cent; while the birds that received 25 per cent of hog pancreas in their food showed an average survival period of 41 days and a loss in weight of only 9.6 per cent. Two birds receiving this ration were in good condition at the close of the test on the fifty-fifth day.

The changes in the weights of the pigeons during the test are shown in Figures 39 and 40.

TABLE 24.—*Experimental feeding of dried calf pancreas and hog pancreas with polished rice.*

Pancreas ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 75.		*Days.*	*Per cent.*	
15 per cent calf pancreas	73	37	−34.9	Died, inanition.
Do	75	47	−38.3	Polyneuritis.
Do	69	35	−11.3	Do.
Do	86	24	−44.3	Died, inanition.
Average		36	−32.2	
PEN 76.				
25 per cent calf pancreas	8	32	−32.3	Polyneuritis.
Do	81	55	−42.9	Very thin, weak, end of test.
Do	89	25	−24.5	Polyneuritis.
Do	96	30	−35.8	Died.
Average		36	−34.1	
PEN 77.				
15 per cent hog pancreas	26	17	−11.6	Polyneuritis.
Do	79	52	−50.3	Died, inanition.
Do	82	10	−5.1	Polyneuritis.
Do	87	35	−25.9	Do.
Average		29	−23.2	
PEN 78.				
25 per cent hog pancreas	80	17	−6.2	Do.
Do	98	55	−10.1	Good condition end of test.
Do	181	55	−1.9	Do.
Do	192	38	−20.3	Died.
Average		41	−9.6	

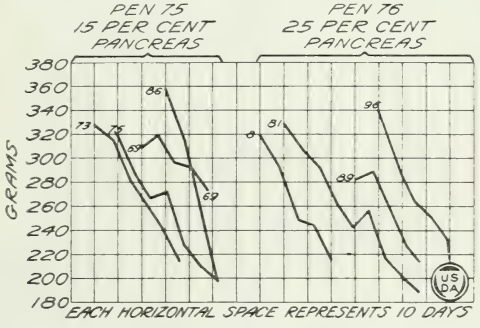

FIG. 39.—Dried calf pancreas; changes in weights of pigeons fed.

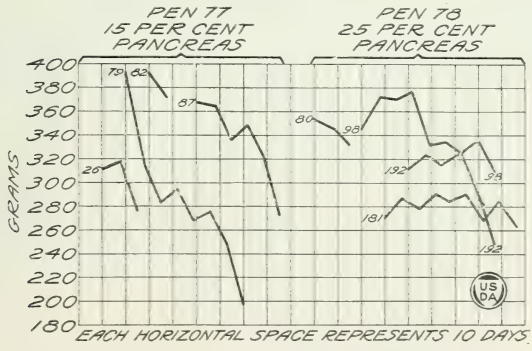

FIG. 40.—Dried hog pancreas; changes in weights of pigeons fed.

TESTS WITH CALF THYMUS AND HOG CHITTERLINGS.

The thymus gland of the calf is the true sweetbread. Chitterlings are that part of the intestinal tract of the hog used as food; and the product used in these tests was cooked chitterlings. In Table 25 are reported the results of the feeding tests with the above-named tissues. The ration containing 15 per cent of calf thymus had a low antineuritic value, the average survival period being only 23 days, and the ration which contained 25 per cent of the tissue had only a fair value, the average survival period of the birds being 34 days.

The chitterlings tested had a fair antineuritic value. All the pigeons which were fed the ration containing 15 per cent of the chitterlings developed polyneuritis by the thirty-ninth day, and the three birds that received 25 per cent of the tissue in their feed all developed polyneuritis by the fifty-second day. The fourth bird in this pen died a few days after the start of the test from an unknown cause. It appears that the calf thymus and hog chitterlings tested had practically the same antineuritic value.

The changes in the weights of the pigeons during the test are shown in Figures 41 and 42.

TABLE 25.—*Experimental feeding of dried calf thymus and hog chitterlings with polished rice.*

Thymus and chitterlings rations.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 79.		*Days.*	*Per cent.*	
15 per cent calf thymus	92	15	−7.3	Polyneuritis.
Do	93	35	−24.4	Died.
Do	94	26	−19.6	Polyneuritis.
Do	95	14	−14.3	Do.
Average		23	−16.4	
PEN 80.				
25 per cent calf thymus	88	25	−14.2	Removed account badly infected eyes.
Do	89	55	−24.5	Fair condition end of test.
Do	90	35	+.7	Polyneuritis.
Do	91	22	+6.6	Do.
Average		34	−7.9	
PEN 81.				
15 per cent chitterlings	9	19	−10.3	Polyneuritis.
Do	10	15	−6.7	Do.
Do	11	39	−34.3	Do.
Do	70	19	−15.4	Do.
Average		23	−16.7	
PEN 82.				
25 per cent chitterlings	13	17	−.6	Polyneuritis.
Do	15	46	−22.4	Do.
Do	16	52	−14.8	Do.
Average		38	−12.6	

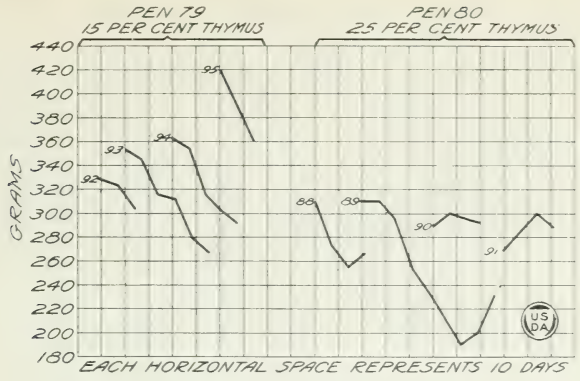

FIG. 41.—Dried calf thymus; changes in weights of pigeons fed.

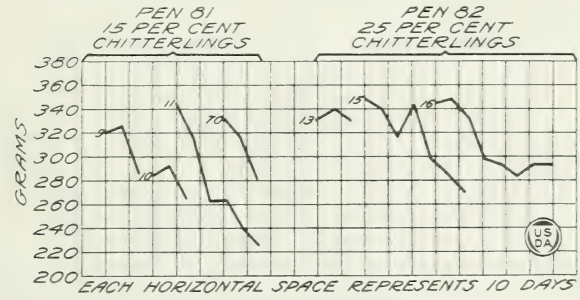

Fig. 42.—Dried hog chitterlings; changes in weights of pigeons fed.

TESTS WITH TRIPE AND HOG STOMACH.

Tripe is prepared from the walls of the first and second stomachs of the ox. It is partially cooked during preparation for food purposes. Hog stomachs are commonly used either as containers for certain sausage products or in the preparation of sausage. Both the tripe and the hog stomachs used in these tests had been cooked according to the regular commercial practice. The results of the feeding tests with tripe and hog stomach are presented in Table 26. From a glance at this table it is at once apparent that each of the products has a very low antineuritic value. It is of interest to note that of the 16 pigeons that were fed the rations containing tripe and hog stomach, 14 developed polyneuritis by the twenty-ninth day of the test, one on the forty-second day, and one died on the twentieth day without showing positive symptoms of polyneuritis. It may be noted also that the average loss in weight of each of the several pens of pigeons was large, ranging from 16.9 to 21.8 per cent.

The changes in the weights of the pigeons during the tests are shown in Figures 43 and 44.

TABLE 26.—*Experimental feeding of dried cooked tripe and hog stomach with polished rice*

Tripe and stomach rations.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 83.				
		Days.	*Per cent.*	
15 per cent tripe	1	24	−24.5	Polyneuritis.
Do	2	19	−13.1	Do.
Do	3	29	−28.8	Do.
Do	4	19	−11.9	Do.
Average		23	−19.6	
PEN 84.				
25 per cent tripe	86	13	−11.7	Do.
Do	6	20	−20.0	Died.
Do	7	17	−11.8	Polyneuritis.
Do	8	19	−24.2	Do.
Average		17	−16.9	
PEN 85.				
15 per cent hog stomach	25	42	−30.2	Do.
Do	26	28	−23.0	Do.
Do	27	20	− 5.8	Do.
Do	28	20	−12.0	Do
Average		28	−17.8	
PEN 86.				
25 per cent hog stomach	29	28	−21.7	Do.
Do	30	17	−24.2	Do.
Do	31	25	−11.6	Do.
Do	32	28	−29.6	Do.
Average		25	−21.8	

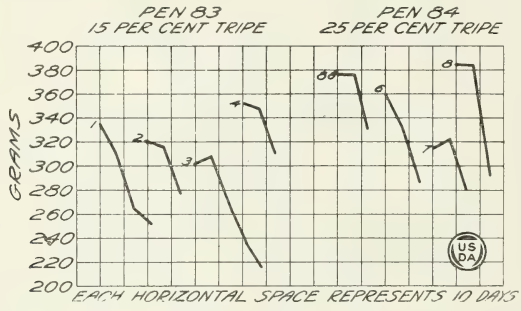

FIG. 43.—Dried cooked tripe; changes in weights of pigeons fed.

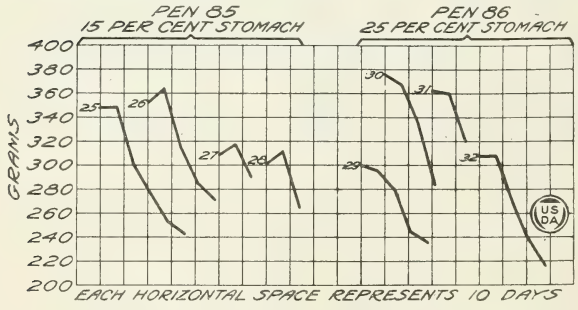

FIG. 44.—Dried cooked hog stomach; changes in weights of pigeons fed.

TESTS WITH OX BLOOD AND CALF BLOOD.

Information regarding the vitamin content of blood is of interest, not only on account of its importance as a food, but also because blood acts as a carrier of vitamins to the tissues.

Samples of defibrinated blood were obtained fresh from a local meat-packing establishment. The serum, which was separated from the corpuscles by means of a centrifuge, was only slightly colored with hemoglobin. The corpuscles were washed several times with normal salt solution. The whole defibrinated blood, the serum, and the corpuscles were dried in the usual way. The results of the feeding tests with these products are shown in Table 27.

The ration containing 15 per cent of ox blood had a very low antineuritic value, the average survival period of the pen of birds getting this ration being only 17 days, while the average loss in weight was 17.6 per cent. The calf blood had a slightly higher value, the average survival period being 31 days, but the loss in weight was 35 per cent. The ox-blood corpuscles had a lower antineuritic value than the whole blood, the average survival period of the two birds getting this ration being only 10 days, while the loss in weight was 23.6 per cent. The very short survival period of the pigeons receiving the ration containing 15 per cent of corpuscles suggests that the presence of this constituent in the ration actually hastened the development of polyneuritis, since it is unusual for pigeons to develop polyneuritis in so short a time, even on a ration consisting entirely of autoclaved polished rice. More experimental evidence is needed to determine this point. The ox-blood serum had a somewhat higher antineuritic value than the whole blood, and a considerably higher value than the corpuscles. However, the serum must be considered as having a low antineuritic value as compared with most

TABLE 27.—*Experimental feeding of dried ox blood and calf blood with polished rice.*

Blood ration.	Pigeon No.	Survival period.	Change in weight.	Result.
PEN 87.		*Days.*	*Per cent.*	
15 per cent ox blood	43	12	−19.9	Polyneuritis.
Do	44	19	−19.8	Do.
Do	45	20	−13.2	Do.
Average		17	−17.6	
PEN 88.				
15 per cent calf blood	46	21	−44.2	Extreme inanition.
Do	47	55	−39.9	Do.
Do	48	17	−20.8	Polyneuritis.
Average		31	−35.0	
PEN 89.				
15 per cent ox-blood corpuscles	5	9	−16.7	Do.
Do	6	11	−30.4	Do.
Average		10	−23.6	
PEN 90.				
15 per cent ox-blood serum	14	35	−30.1	Died.
Do	15	14	−13.2	Polyneuritis.
Average		25	−21.7	

of the other animal products that have been tested. Figure 45 shows the changes in weight of the pigeons fed the blood rations.

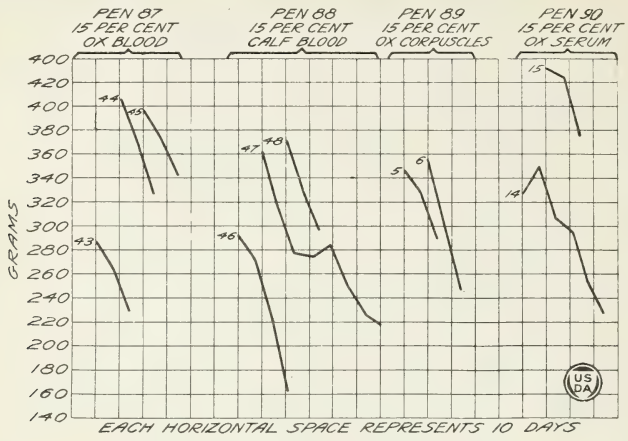

FIG. 45.—Dried ox and calf blood; changes in weights of pigeons fed

SUMMARY OF PART II.

In order to facilitate the interpretation of the results of the experiments reported in Part II of this bulletin Table 28 has been prepared in which are set forth the average data for each pen of pigeons fed. As has been stated before, the antineuritic value of a ration fed to pigeons must be judged, not only by the survival period of the birds, but also by the changes in their weights; and that basis for judgment has been followed here.

The results of the experiments to determine the relative antineuritic properties of the edible viscera and blood from the ox, sheep, and hog may be summarized as follows:

I. ANTINEURITIC VALUES OF DIFFERENT ORGANS AND BLOOD FROM THE OX, HOG, AND SHEEP, RESPECTIVELY.

The ox.—The heart had the highest value, followed closely by the kidney, and the liver. The other products had considerably lower values in the following order: Spleen, lungs, brain, calf thymus, calf pancreas, tripe, serum, ox blood, calf blood, and ox-blood corpuscles.

The hog.—The heart and liver had practically the same value and the kidney a slightly lower value. The spleen, pancreas, chitterlings, and stomach, in order, had much lower values.

The sheep.—The heart had the highest value, followed closely by the liver. The brain and lungs, in order, had much lower values.

II. ANTINEURITIC VALUES OF THE SAME ORGAN FROM THE OX, SHEEP, AND HOG.

Hog liver had the highest antineuritic value, but there was not much difference in the values of ox, calf, and lamb liver.

The heart, kidney, spleen, brain, lungs, pancreas, stomach, and blood, respectively, each had practically the same antineuritic value regardless of source.

III. EFFECT OF HEATING UPON THE ANTINEURITIC PROPERTIES OF OX LIVER, HEART, AND KIDNEY.

The results of the tests which have been reported in this bulletin are summarized in Table 29. The data indicate that ox liver, heart, and kidney suffered material reduction in their antineuritic properties on cooking, the extent of the damage depending upon the temperature and time of cooking. However, fried and baked ox liver and cooked ox heart and kidney still had very fair antineuritic values.

TABLE 28.—*Summary of antineuritic properties of edible viscera (from the ox, sheep, and hog), fed with polished rice.*

Pen No.	Ration.	Test period.[1]	Survival period.	Change in weight.
		Days.	*Days.*	*Per cent.*
35	5 per cent ox liver	55	42	−20.9
36	15 per cent ox liver	55	44	−9.4
37	30 per cent ox liver	105	102	+7.6
38	5 per cent calf liver	75	40	−36.3
39	15 per cent calf liver	75	56	−19.9
40	30 per cent calf liver	75	66	−1.2
41	15 per cent lamb liver	70	21	−11.4
42	25 per cent lamb liver	70	62	−3.1
43	15 per cent hog liver	70	62	+4.0
44	25 per cent hog liver	70	70	+12.1
45	15 per cent ox heart	55	55	+13.5
46	25 per cent ox heart	55	55	+14.3
47	15 per cent hog heart	55	55	+6.9
48	25 per cent hog heart	55	55	+12.4
49	15 per cent lamb heart	63	63	−0.3
50	25 per cent lamb heart	63	53	+12.2
51	15 per cent ox kidney	63	63	−4.0
52	25 per cent ox kidney	63	63	+6.3
53	15 per cent hog kidney	63	63	+0.03
54	25 per cent hog kidney	63	63	+8.9
55	15 per cent ox spleen	57	56	−13.0
56	25 per cent ox spleen	57	57	−15.6
57	15 per cent hog spleen	57	55	−15.2
58	25 per cent hog spleen	57	57	−20.4
67	15 per cent ox brains	55	26	−9.7
68	25 per cent ox brains	55	41	−6.7
69	15 per cent lamb brains	55	29	−12.8
70	25 per cent lamb brains	55	45	−2.0
71	15 per cent ox lungs	55	49	−11.4
72	25 per cent ox lungs	55	55	−19.2
73	15 per cent lamb lungs	55	33	−12.0
74	25 per cent lamb lungs	55	51	−21.3
75	15 per cent calf pancreas	55	36	−32.3
76	25 per cent calf pancreas	55	36	−34.1
77	15 per cent hog pancreas	55	29	−23.2
78	25 per cent hog pancreas	55	41	−9.6
79	15 per cent calf thymus	55	23	−16.4
80	25 per cent calf thymus	55	34	−7.9
81	15 per cent hog chitterlings	55	23	−16.7
82	25 per cent hog chitterlings	55	38	−12.6
83	15 per cent tripe	55	23	−19.6
84	25 per cent tripe	55	17	−16.9
85	15 per cent hog stomach	55	28	−17.8
86	25 per cent hog stomach	55	25	−21.8
87	15 per cent ox blood	55	17	−17.6
88	25 per cent ox blood	55	31	−35.0
89	15 per cent ox-blood corpuscles	55	10	−23.6
90	15 per cent ox-blood serum	55	25	−21.7

[1] The term "test period" indicates the duration of a feeding test which includes a number of pens of pigeons, and the term is not synonymous with "survival period" which has already been defined. The survival period of a pigeon must be considered in relation to the length of the test period as well as to the change in weight of the bird in order to appraise the antineuritic value of the ration fed. In the earlier work with animal tissues, test periods of different length were employed, but in recent work an eight-week test has been adopted as standard.

TABLE 29.—*Summary of effects of heating upon antineuritic values of ox liver, heart, and kidney fed with polished rice.*

Pen No.	Ration.	Test period.	Survival period.	Change in weight.
		Days.	*Days.*	*Per cent.*
59	30 per cent ox liver heated 2 hours at 100° C.	70	23	−15.1
60	30 per cent ox liver heated 2 hours at 124° C. in autoclave	70	22	−18.0
61	30 per cent ox liver heated 2 hours at 130° C. in autoclave	70	31	−32.9
62	25 per cent fried ox liver	70	59	−11.0
63	25 per cent ox liver baked 30 minutes at 186° C.	55	51	−2.3
64	15 per cent cooked ox heart	59	44	−7.9
65	15 per cent cooked ox kidney	56	38	−17.5
66	25 per cent cooked ox kidney	56	56	−13.0

CONCLUSIONS.

1. Meat may be regarded as an important source of vitamin B in the diet. Pork in particular—that is, the lean meat—is rich in this vitamin, comparing favorably in this respect with liver and kidney, organs heretofore recognized as containing an abundance of vitamin B. Beef appears to contain a much smaller proportion of the vitamin, while mutton occupies an intermediate position.

2. Several of the internal organs are particularly rich in vitamin B. The heart appears to be the richest in this vitamin, but the liver and kidney have only slightly lower values. The other organs contain smaller quantities of the vitamin. This class of products is an important and economical source of vitamin B.

REFERENCES TO LITERATURE.

(1) Roberts, John. 1922. Food animals and meat consumption in United States, 1907–1921. Circular 241, U. S. Dept. of Agr., Bureau Animal Industry.
(2) Langworthy, C. F., and Hunt, Caroline L. 1910. Economical use of meat in the home. Farmers' Bulletin 391, U. S. Dept. Agr.
(3) Sherman, H. C. 1918. Chemistry of Food and Nutrition, 2d ed., p. 387.
(4) Eykman, C. 1906. Über Ernährungspolyneuritis. In Arch. Hyg., v. 58, p. 150.
(5) Watson, C., and Hunter, A. 1906. The influence of diet on growth and nutrition. In Journ. Physiol., v. 34, p. 111.
(6) Cooper, E. A. 1912. On the protective and curative properties of certain foodstuffs against polyneuritis induced in birds by a diet of polished rice. In Journ. Hyg., v. 12, p. 436.
(7) Osborne, T. B., and Mendel, L. 1917. Nutritive factors in animal tissues. I. In Journ. Biol. Chem., v. 32, p. 309.
(8) Cole, Sydney W. 1917. Report on a dried meat powder. Report British Food War Comm., No. 42.
(9) Voegtlin, Carl, and Lake, G. C. 1919. Experimental mammalian polyneuritis produced by a deficient diet. In Journ. Physiol., v. 47, p. 558.
(10) McCollum, E. V., Simmonds, Nina, and Parsons, H. T. 1921. I. The nutritive properties of animal tissues. In Journ. Biol. Chem., v. 47, p. 111.
(11) Dutcher, R. A., Eckles, C. H., Dahle, C. D., Mead, S. W., and Schaefer, O. G. 1920. The influence of diet of the cow upon the nutritive and anti-scorbutic properties of cow's milk. In Journ. Biol. Chem., v. 45, p. 119.
(12) Drummond, J. C., Golding, G., Zilva, S. S., and Howard, K. H. 1920. The nutritive value of lard. In Biochem. Journ., v. 14, p. 742.
(13) Drummond, J. C., Coward, K. H., and Watson, A. F. 1921. Notes on the factors influencing the value of milk and butter as sources of vitamin A. In Biochem. Journ., v. 15, p. 540.
(14) Kennedy, Cornelia, and Dutcher, R. A. 1922. The influence of the diet of the cow upon the quantity of vitamins A and B in milk. In Journ. Biol. Chem., v. 50, p. 339.
(15) Cooper, E. A. 1914. Protective and curative properties of certain foodstuffs against polyneuritis induced in birds by a diet of polished rice. In Journ. Hyg., v. 14, p. 12.
(16) McCollum, E. V., and Davis, M. 1915. The influence of certain vegetable fats on growth. In Journ. Biol. Chem., v. 21, p. 179.
(17) Eddy, Walter H. 1916. The isolation of a growth promoting substance from sheep pancreas. In Journ. Biol. Chem., v. 27, p. 113.
(18) Osborne, T. B., and Mendel, L. 1918. Nutritive factors in animal tissues. II. In Journ. Biol. Chem., v. 34, p. 17.

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